

The Blast Furnace *and* Steel Plant

Fifty Years of Iron and Steel

The Influence of Many Discoveries and Inventions Upon the Iron and Steel Industry of the United States Described in a Remarkable Review.

By JOSEPH G. BUTLER

Vice President Brier Hill Steel Company.

SIXTY years ago there was no such thing as the steel business in America. The trifling production of "blister" steel, amounting to about 2,000 tons per year, was not worthy of that designation. But the iron business had already laid the foundations of its future greatness. And this in spite of the fact that we had then comparatively no ores, no efficient fuel, no adequate machinery and very little of the practical and scientific knowledge so widely diffused to-day.

When I entered the iron business, we made iron without coke—a task resembling that of the Hebrews who were compelled to make bricks without straw. We had what would now be considered no ore, for the chief supply was derived from an occasional pocket in the hills or gathered from swamps or the beds of creeks. We had no furnace tops, no blast stoves, no hot blast as we know it now, no metallurgists, and, in the light of the present experience, no markets. We knew nothing of the value of gas, natural or manufactured, a fuel indispensable in the manufacture of iron and steel in large quantities. But we did have grit and energy, the determination to do our best, and the same pride in doing things that we have now.

There was at that time no thought of making steel at the ordinary iron works. The equipment consisted of one or more small heating furnaces, one or two

trains of rolls, perhaps a forge fire or two, a few puddling furnaces and occasionally some machinery for making cut nails. The product was usually either simply pig iron, or merchant bars, a commodity which, by the way, has not changed its name in the whole 250 years since iron was first formed by forging into that shape.



There is probably no one in the country who is more intimately acquainted with the development of the steel industry during the last half century than Joseph G. Butler. Quoting his own words: "This period covers the greatest progress the world has ever known. It has brought forth so many startling discoveries, so many striking inventions, so many achievements enriching and broadening human life, that merely to mention all of these would be a tedious task." In this article "Uncle Joe," as he is affectionately known, relates the development of the great industry in such a fascinating manner that it might well be called "The Romance of Iron and Steel."

The "Bessemer" Process Invented by an American.

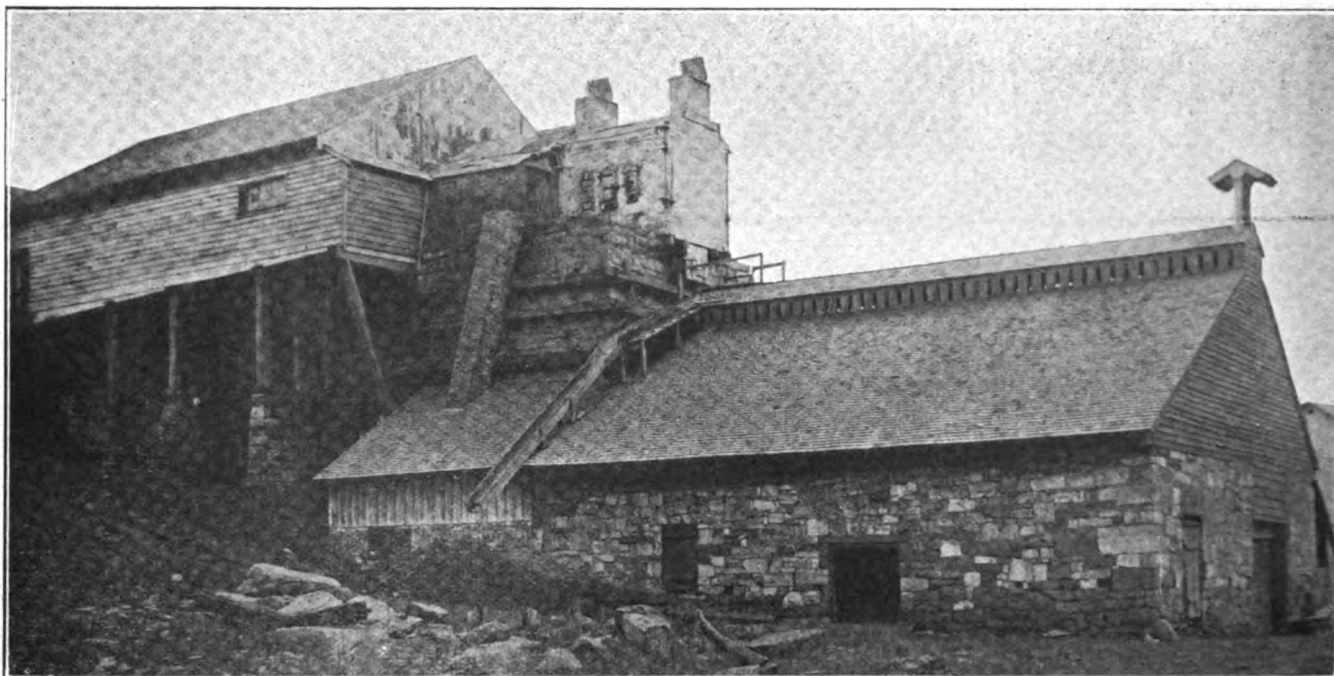
The steel business was really born in America when the Bessemer process came in use here, which was not until about 1864. The idea of removing carbon and silicon from blast furnace iron in this way was undoubtedly first con-

ceived by an American, although he failed to develop the machinery for its use, and, as a consequence, reaped very little benefit from it. When William Kelly, who first decarburized iron by means of an air blast in a furnace he had erected for that purpose at Eddyville, Ky., about 1850, came to file his claim for a patent in 1856 he found that Henry Bessemer had filed similar claims and been granted patents a few days previously. Kelly had worked for years on his scheme, which was identical in principle, but he had not yet made it a commercial success and did not attempt to make steel in that manner. Nevertheless, his use of the pneumatic process first was not disputed and he was granted an interference as against the Bessemer patent.

Other Important Discoveries and Inventions.

The invention of the Bessemer process, or rather

Abstract of paper read before the fall meeting of the American Iron and Steel Institute.



Frankstown furnace, Blair county, Pa., formerly operated by Peter Schoenberger.

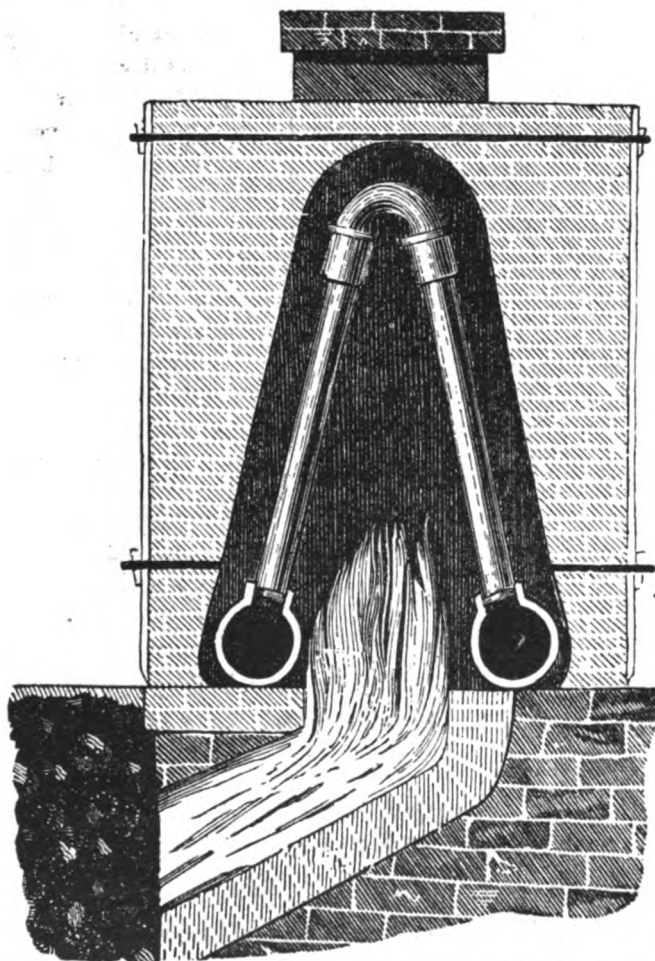
its perfection and development, is generally regarded as the longest single step in the march of progress that has brought the iron and steel industries to their present stage, but there are other discoveries that

seem to me even more important. We cannot make steel without iron, and therefore of even more moment than this invention were such things as the discovery of the Lake Superior ore ranges, the invention of the furnace top, the use of coke and its economical manufacture, the development of high blast temperatures, and especially in view of its recent rapid adoption, the Siemens-Martin open hearth furnace.

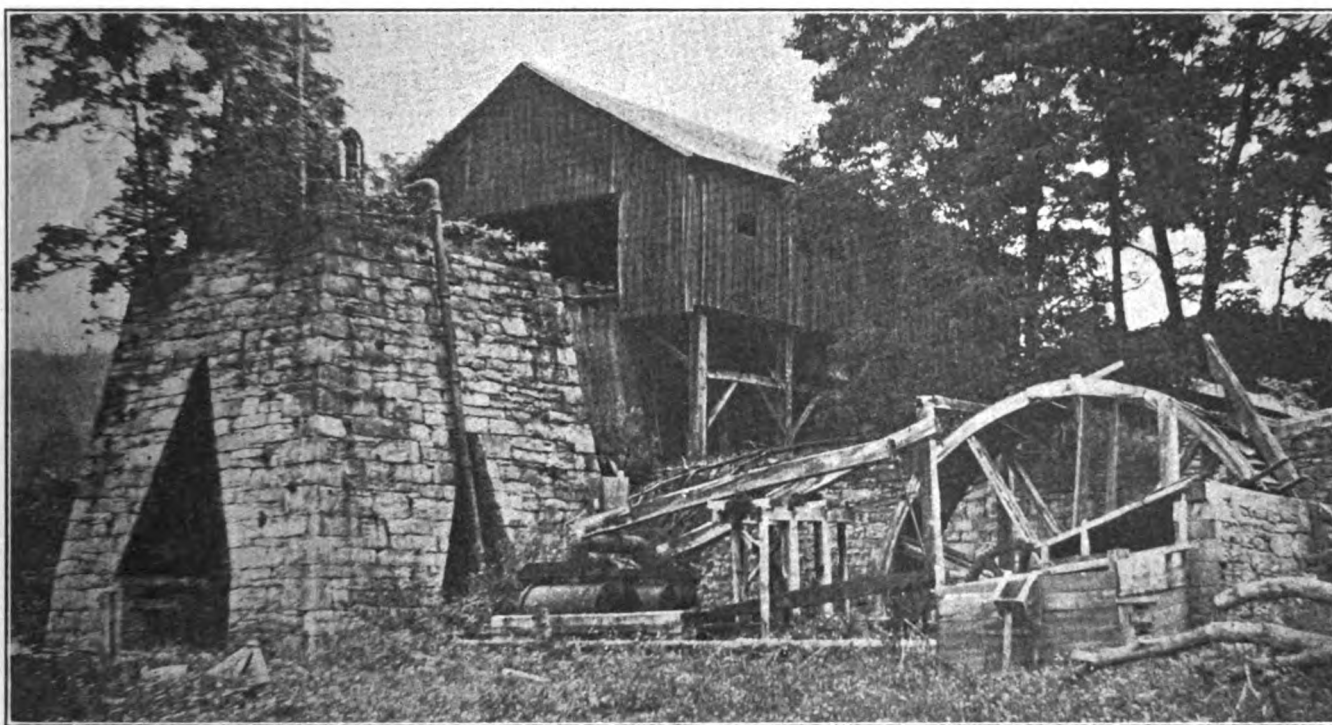
As has been stated, I met Mr. Kelly when he was trying to make his great discovery a practical success. I saw him on a number of occasions later, when he was working to unravel the skein of litigation that tied up the Bessemer process and prevented its adoption in this country until 10 years after it was patented here. I can recall the announcement in the technical journals of that day of the discovery by Robert Mushet, a Scotsman, that spiegeleisen would recarburize iron blown in a converter and thus produce steel. We did not know of this in America for some time after Mushet's patents were granted in England, which was in the latter part of 1856. Up to that time Kelly did not suspect that he had found a new way to make steel, and had urged his process on iron manufacturers only as a cheap and rapid method of purifying iron for rolling mills, claiming that it would take the place of puddling, something it has, by the way, never done.

Development of the Hot Blast.

Likewise I was privileged to watch every step in the development of the hot blast. At the Ward furnace at Niles, and in other furnaces in the valley, the blast was heated by passing it through cast iron pipes. These pipes lasted but a short time. Their renewal and replacement kept the local foundries busy, inter-



Section showing former method of heating blast.



This illustration shows the water wheel at the right which supplied power for the blowing cylinders seen in the center—The blast was heated by means of the pipes shown at the top of the furnace.

fering seriously with continuous operation. We had what we called a hot blast, but it was really only warm in comparison with modern practice. The furnacemen tested its temperature with lead and zinc, strips of which were inserted at the point where it entered the furnace. If the blast did not melt lead it was not quite hot enough, and if it melted zinc it was too hot, so we believed, and would burn the iron.

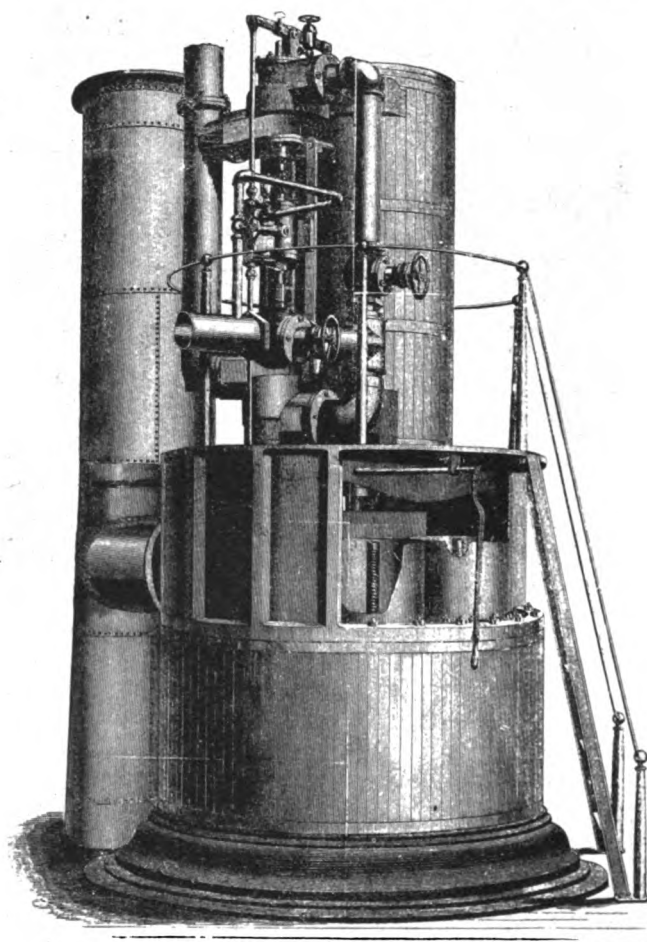
It was about 1868 that the Player hot blast stove was brought from England to this country. I was a decided improvement. This stove introduced an innovation in being located on the ground instead of at the tunnel-head. The first stove to employ the regenerative principle was the Whitwell stove, and it was lined with firebrick, also a new idea. Both it and the Player stoves immediately increased the output of furnaces and made larger stacks possible, although it was many years before they supplanted the old Thomas stoves at many American furnaces.

The Use of Furnace Gas Introduced Here by Germans.

The use of furnace gas for heating the blast in this country we owe to the Germans, the first to bring these gases down and burn them under stoves and boiler in America having been made about 1859 by C. E. Detmold, a German engineer residing in New York. The new plan cost a good deal of money and for that reason was slowly adopted. We did not get to it in Ohio for some years after it was used in the East. I recall very distinctly the first furnace top installed at Youngstown. It was thought highly dangerous by the workmen, and there was at first some difficulty in getting them to work around the stack.

With the use of better stoves and the introduction

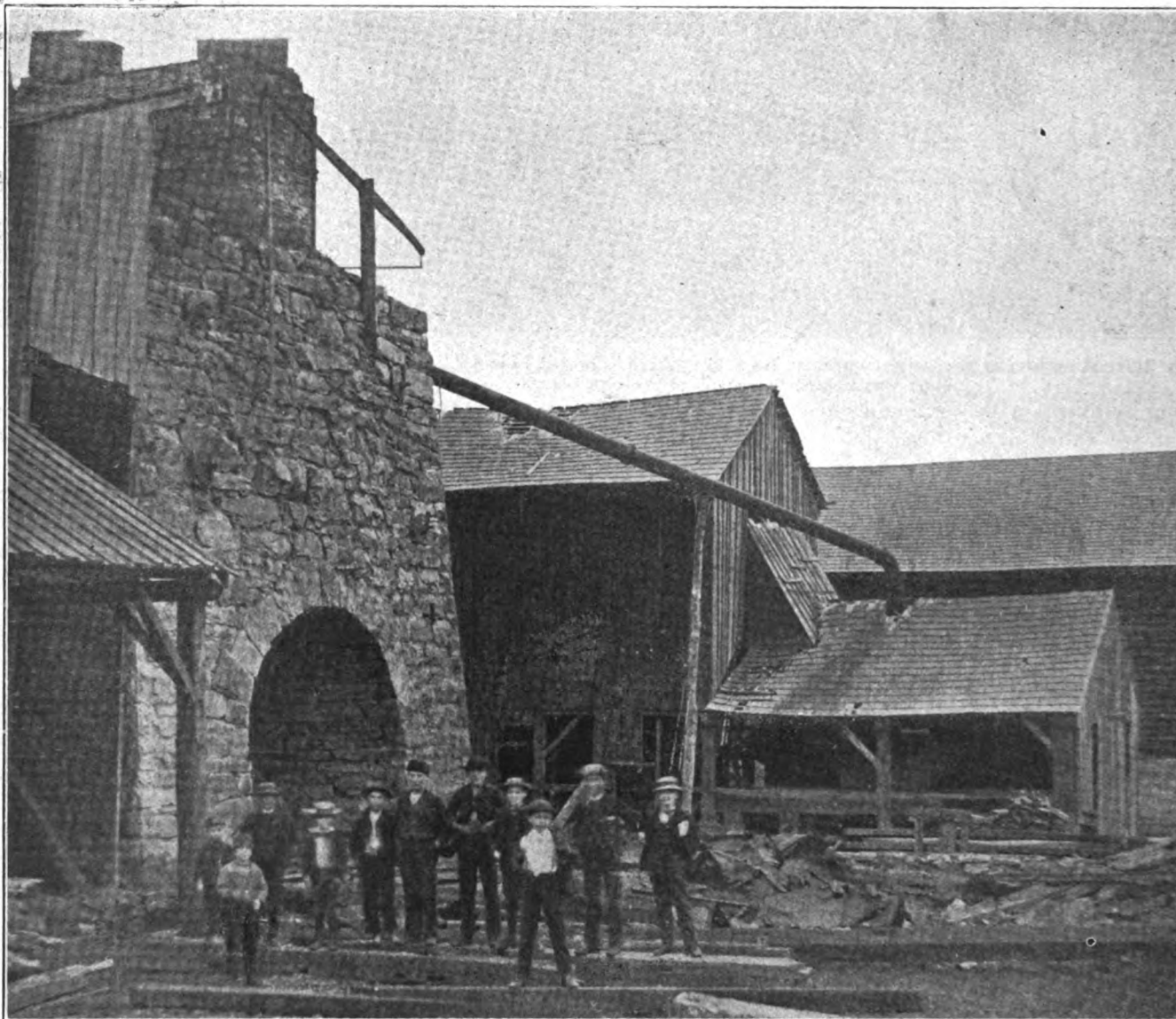
of more powerful blowing engines, furnaces began to grow in size and more attention was paid to their lines. It was realized that much improvement could be made in the output, and progress in this direction



Upright blowing engine in use about 1860.

was rapid. By 1875 it was known that blast furnaces could be operated successfully up to 80 feet in height, and, with coke for fuel and proper equipment for blowing and heating the blast, could be made to yield much larger product than had been expected up to that time. But it was not until about 1880 that one of these larger furnaces reached an output much above 100 tons per day. This was the Isabella, located at Etna, near Pittsburgh. During three years 1881,

stack was usually about 35 feet in height and built of masonry, lined on the inside with a poor quality of fire-brick. It was square in section, on the outside, the bottom being about 24 feet each way and the top somewhat smaller, this depending on the opinion of the man who designed it. The stack was usually located against a bluff, the double purpose being to make construction cheaper by using the hill to reinforce one side and enable a patient mule to perform



This furnace, standing in Conemaugh, Pa., was formerly operated by the Cambria Iron Company.

1882, 1883, this furnace produced an average of 1,090 tons per week—the best ever done by a blast furnace up to that time in this or any other country.

The Picturesque Old Furnaces.

To those who have had experience only with the present-day blast furnace and modern furnace practice, it is impossible to portray the conditions surrounding this industry at the time when I first became interested in it. The old stack of those days, with its equipment, would be picturesque in the extreme, if it could be set up in the vicinity of a modern steel works. The

functions of a skip hoist by dragging the ore to the top of the hill. A short bridge connected the stockhouse with the top and the material was wheeled from this point and dumped in at the open top.

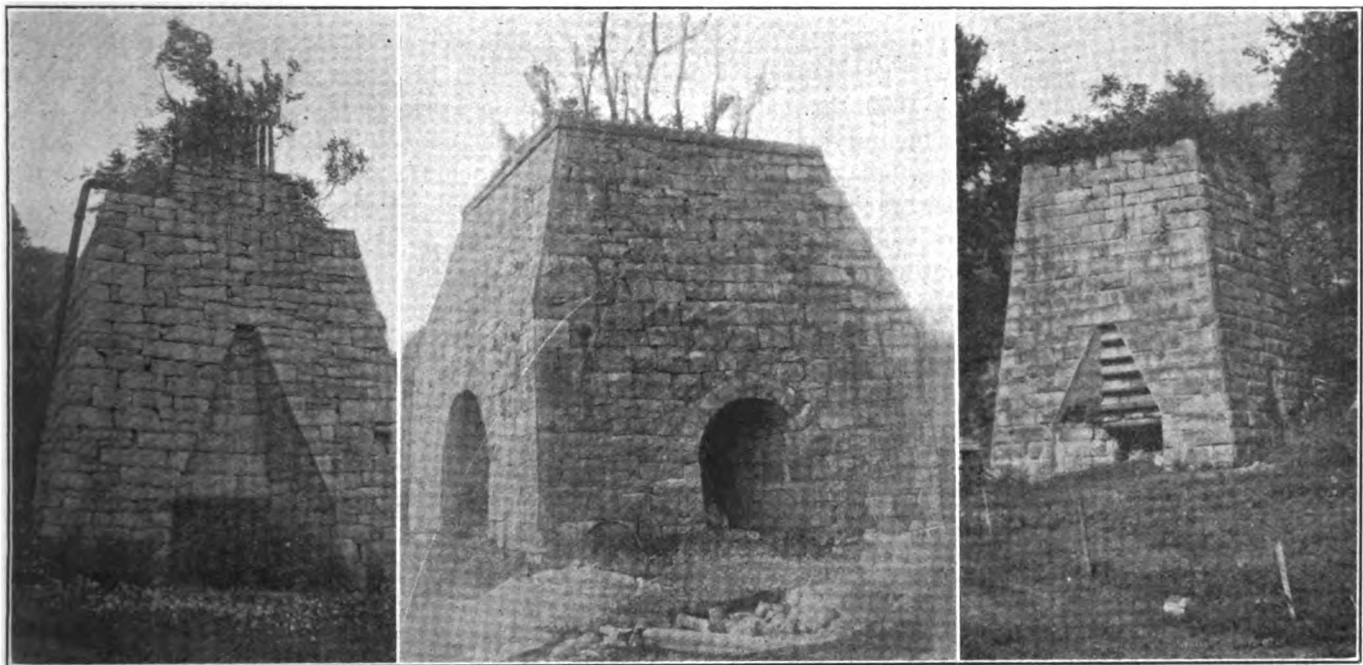
Only one or two tuyeres were used, and these were often on the same side of the stack, next to the blowing engine. In front was the sand bed, into which the iron was run, and to one side the space reserved for roasting the ores. No water-cooling devices were used except at the tuyeres and the opening in front. It was a very small proposition compared with what

we are used to at this time, but was, nevertheless, a source of general public interest and regarded with considerable awe by the uninitiated. I can recall the first furnace in our district whose builders had nerve to locate it away from a hill. They used a hoisting device in which a tank filled with water raised the platform on which two wheelbarrows loaded with ore had been placed. When the barrows were dumped they were wheeled back on the platform, the water was let out of the tank at the other end of the rope and they came down to be refilled.

The blowing engines were of the crudest type and had but little power. There was then no method of gaging the pressure accurately and this was one of the cares of the furnace boss. He was expected also to know when the furnace was ready to cast, the

The Introduction of Coke.

About 1860 the first coke was regularly used as fuel in a furnace at Pittsburgh, and within a few years it proved so efficient that all other fuels were practically eliminated except for making special grades of iron. When I first became interested in the furnace business, all the stacks in the Mahoning valley, as well as those in Hocking valley, at Canal Dover, and at several other points in Ohio, were using raw coal. It was to a rich deposit of black-band ore found underneath the coal at Mineral Ridge, near Niles, and the equally important discovery at Brier Hill, in Youngstown, of coal making a fairly good fuel in its raw state, an almost natural coke, that the development of iron business in the Mahoning valley was due. This coal, very similar to the Scotch coal afterwards found in



On left, Old River furnace, Vintondale, Pa., operated by Peter Schoenberger; in center, Laurel Hill charcoal furnace, Power Mill Run, Westmoreland county, Pa.; on right, old furnace in Kentucky.

proper color of the iron, and a great many other things. As a rule he did not know these things better than might be expected, and these old furnaces made good iron even if they did not make much of it.

Even this type of furnace was a great improvement over these in use 40 years earlier in that locality, for these used the "trompe" or water blast, which was, you may be sure, somewhat removed from the Gayley dry blast. This was a contrivance by which a waterfall was made to carry air into a box, compressing it in the top, from which it was carried to the furnace through a small pipe.

It is a curious circumstance that the first furnace erected by the Carnegie Steel Company was one torn down at Escanaba and taken to Pittsburgh. It had been erected in Michigan to be near the ore fields, but its owners found that the problems of transportation could not be solved in that way alone.

other parts of Ohio, was rich in carbon and low in ash, and in the hands of those who understood it, made a better blast furnace fuel than had yet been found at its low cost. For years it was mined close to the stacks and hauled by mules. All of the ore, usually a mixture of black-band, kidney and bog ores, had to be roasted before charging, and this was done with wood and coal in great heaps near the furnaces. The output of the four furnaces then in operation in that district was certainly not more than 250 tons per week. From this has grown a business employing 50 blast furnaces and producing, during 1916, 6,923,938 tons of pig iron. From the few small rolling mill plants then in that neighborhood have been evolved 46 modern rolling mills, rolling almost 4,000,000 tons of steel per year.

The employment of coke as a blast furnace fuel was an advance of such importance that it is worth while to refer to it somewhat more comprehensively. It was known in Germany and England long before

its use anywhere in America, where charcoal was at first relatively low in cost. The date and place where coke was first used in this country are not entirely certain, but it was possibly tried in several places at the beginning of the last century. A paragraph in a history of Fayette county, Pa., refers to the use of coke in the Allegheny furnace, Blair county, in 1811. William Firmstone used it for a short time in a furnace at Huntingdon county, Pa., in 1835, but abandoned it later. There seems to be no doubt that he succeeded in making good gray iron with it at the date mentioned, but why he did not continue has never been recorded. In 1856 there were 21 furnaces in Pennsylvania and three in Maryland using coke, but, so far as is known, none west of these states. The census of 1850 enumerates four furnaces as burning coke, and by 1860 21 reported its use. In the next 10 years the census people found only five more plants employing coke, but it is probable there were many who did not report its use at that time. At any rate, by 1880, the census reports enumerated 149 stacks blowing on that fuel.

Coke from that time on rapidly supplanted charcoal and all other fuels, including anthracite coal. It is now used almost exclusively. Out of 465 blast furnaces now in operation or building in this country, only 40 use charcoal, the others being fired with coke, or, in a few instances, with coke and coal mixed. The charcoal furnaces are mainly small and of antiquated type, their output for 1916 being only 635,650 tons of iron as compared with 45,228,875 tons produced in coke-driven stacks. No new charcoal furnaces were reported building in 1916, but 17 coke furnaces, with a capacity of 3,151,000 tons, were under construction at the close of that year.

I have bought many thousands of tons of good beehive coke at 85 cents per ton. The average selling price of the entire output of the country in 1880 was \$1.79 per ton. There were then 7,211 beehive ovens in operation, and the production was 2,205,946 tons. During 1916, according to the estimates at hand, the exact figures not being available, the country's entire production of coke was 54,325,000 tons, and of this 35.35 per cent was made in by-product ovens. Some coke was sold in 1917 as high as \$15 per ton.

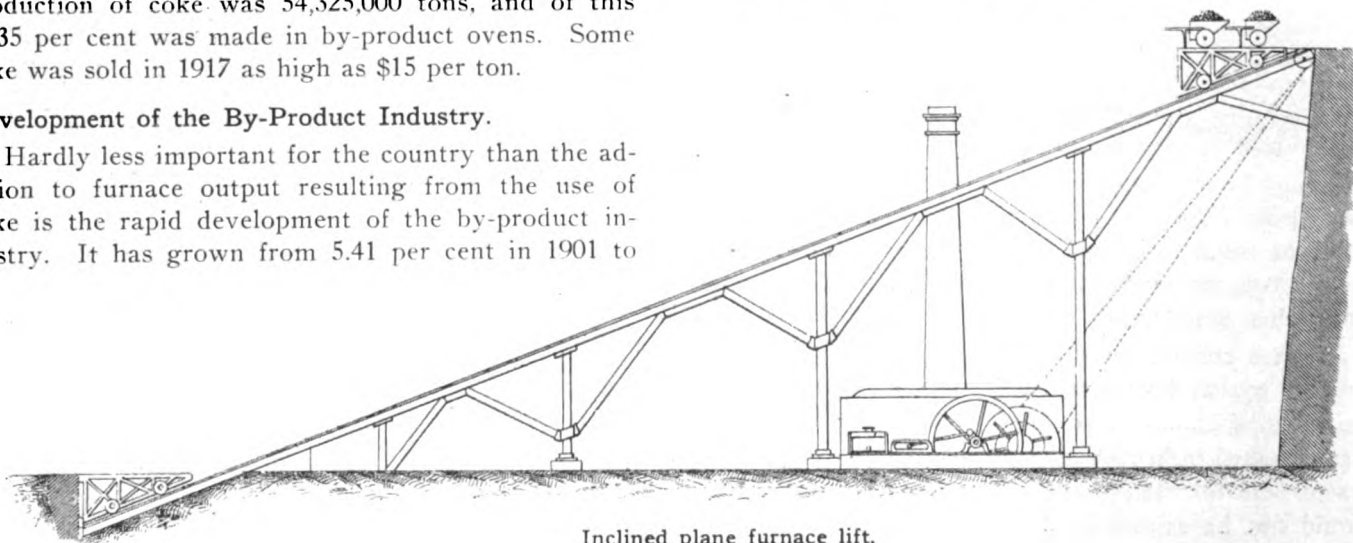
Development of the By-Product Industry.

Hardly less important for the country than the addition to furnace output resulting from the use of coke is the rapid development of the by-product industry. It has grown from 5.41 per cent in 1901 to

35.35 per cent in 1916. No other single development has done so much to conserve the natural resources of America and none has more effectively indicated the energy, wisdom and public-spirit of the men at the head of our iron and steel plants. The erection of by-product plants involves huge sums of money, but they make large profits and save for future generations incalculable natural wealth. It is safe to predict that the wasteful beehive oven will soon take its place in the limbo of great mistakes, among the dust of ignorance, with many other things that were once hailed as great discoveries and thought to be the limit of human knowledge.

New Sources of Ore Supply.

The development of the Lake Superior ore deposits has exercised on the iron and steel industries of the world an influence more far-reaching than any other incident in their history. Previous to that time furnaces and iron works had been located in many places where ore and fuel could be found. But the time had come when such resources were inadequate to meet the growing needs of the country. Perhaps it would be more accurate to say that the time had come when the further progress of civilization demanded iron ore in quantities and at a cost hitherto undreamed of. There is no question that, from the time of the discovery of the Mesaba range, civilization and progress received a tremendous impulse from the cheaper iron and steel it made possible. From this time it became evident that the production of these commodities had to be on an enormous scale, and that the day of the small furnace was at an end. It became evident, also, that henceforth the industries must be confined to those localities where ore and fuel could be assembled in vast tonnages at low cost and markets reached with the greatest facility. The first effect of this discovery was to practically limit the production of iron and steel in large tonnages to regions most accessible to great ore and fuel deposits. The Pittsburgh and Youngstown districts had no rival in this respect ex-



Inclined plane furnace lift.

cept, perhaps, the Atlantic coast district, where the rich ores of Cuba and South America were available at equal distance from the Connellsville coke field. Even this district is now suffering from the accidental dislocation of ocean freight service and is glad to get ores from Lake Superior, which have no equal in low cost and usefulness. The Birmingham district is now coming to the front also and is playing a great part in the development of the iron and steel industry.

The ravenous ranges were opened for shipment of ore in the following order:

Marquette	1550
Menominee	1870
Gogebic	1884
Vermillion	1884
Mesaba	1893
Michipicoten	1900
Baraboo	1904
Cuyuna	1911

The first regular shipments in cargo down the lakes began somewhat later than the dates mentioned for all these ranges. That from the Marquette was in 1856, the opening of the Sault Ste. Marie Canal in that year having made possible cargoes large for that day, although they would seem insignificant at this time. The total shipment by water from this region in 1856 were only 7,000 tons, about half enough to make a cargo for a modern ore boat. This ore was valued at \$28,000. In 1856 first-class "specular" or "hard" ore from the Marquette range brought \$7 per ton on the docks at Cleveland.

Up to 1908, all the ranges in the Lake Superior region had produced a total of 407,060,116 tons of ore. In 1912 their output had increased to 48,221,346 tons for that year alone, and in 1916 it reached the grand total of 66,658,466 tons, or 11,000,000 tons more than the entire production of the United States in 1915, according to the figures of the United States Geological Survey.

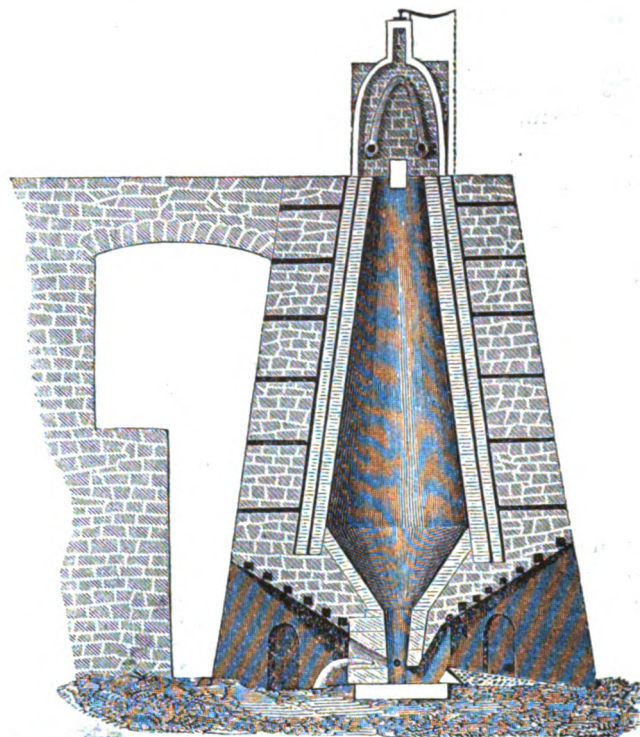
Of this the Mesaba range alone produced 42,525,612 tons, or almost 64 per cent, achieving a record as the greatest source of iron on the globe. The Mesaba range has always led in this respect, and its development has revolutionized the iron and steel industries of the world. Because the ore on this range can be mined with great economy, and because of its close proximity to the lakes, it can furnish ore at a lower cost per ton of iron than it can be laid down in any other part of the world where there are furnaces to smelt it. Equally rich and accessible deposits may exist in India and South America, but it must be remembered that the tropics are not suited to the manufacture of iron, and it is not likely that anything equal to this range will be found within the temperate zones. Because of the conditions on the Mesaba range we have learned to mine ore by stripping, even at a depth of 300 feet, and this of itself has been a long step toward economy in the cost of production.

Improvements in Mining and Transportation.

Following the development of the Mesaba range came

the astounding improvements in mining and transportation of ore which, together with the tremendous supply of that region, have had much to do with the phenomenal growth of the industries.

When we began to use Lake Superior ores the ordinary cargo of a lake boat was 500 tons. It required several days to load and unload this cargo at every point where it had to be handled—four in all. The ore



Section of blast furnace, showing lines, tuyere and method of heating blast at top.

cars then in use carried only 10 tons. When their capacity was increased to 25 tons and boats were built that would carry 1,000 tons, we thought our problems were solved. Now we have vessels loading as high as 12,000 tons at the upper ports in two or three hours with one or two men on the dock, and unloading their cargo directly into 50-ton cars in about the same time and with practically no manual labor.

In the old days men with shovels loaded the ore at the mines into small cars from which it was transferred to railroad cars. They handled it again the same way four times before it reached the furnace, for even the hopper car had not then been invented. Aside from being the most laborious task to which a human back was ever bent, this was extremely costly and slow beyond your belief. Now we handle this vast tonnage entirely by machinery. Steam shovels mine the ore, it flows by gravity into great vessels; huge unloaders transfer it to railroad cars and car dumpers empty it under ore bridges, all the work being done by power and at a sped little short of miraculous. These things were all unknown a half century ago. They are the product of the tireless brains and the unflagging energy of the men who have built our industries to their present colossal proportions.

Development of Blast Furnaces.

The improvements in blast furnace construction and practice referred to in previous paragraphs had much of their inspiration from these changes in the method of handling ores. With them came changes in size, lines and equipment. These changes were most marked during the period between 1860 and 1890. In 1850 there were few furnaces in the country that could produce 150 tons of iron in a week, and the average did not reach that figure until about 1865. In 1890 a furnace at the Edgar Thompson works, built under the design of Julian Kennedy and operated under the direction of Capt. "Bill" Jones, startled the world by yielding 502 tons of iron in one day and 2,462 tons in one week. That was then believed to be the limit of production, but it is now not unusual for stacks to exceed this figure, and there are a few producing 600 tons per day.

In 1860 the total output of pig iron in the United States was 821,223 tons. In 1890 it had risen to 9,202,703 tons. During 1916 there was made in America 39,434,797 tons of pig iron of all grades.

Naturally, the rapid development of the iron industry was closely followed by an equally impressive growth in the production of steel, and this was characterized by the same astonishing increase in the efficiency of machinery and methods for fabricating the product into the countless forms in which it is marketed today.

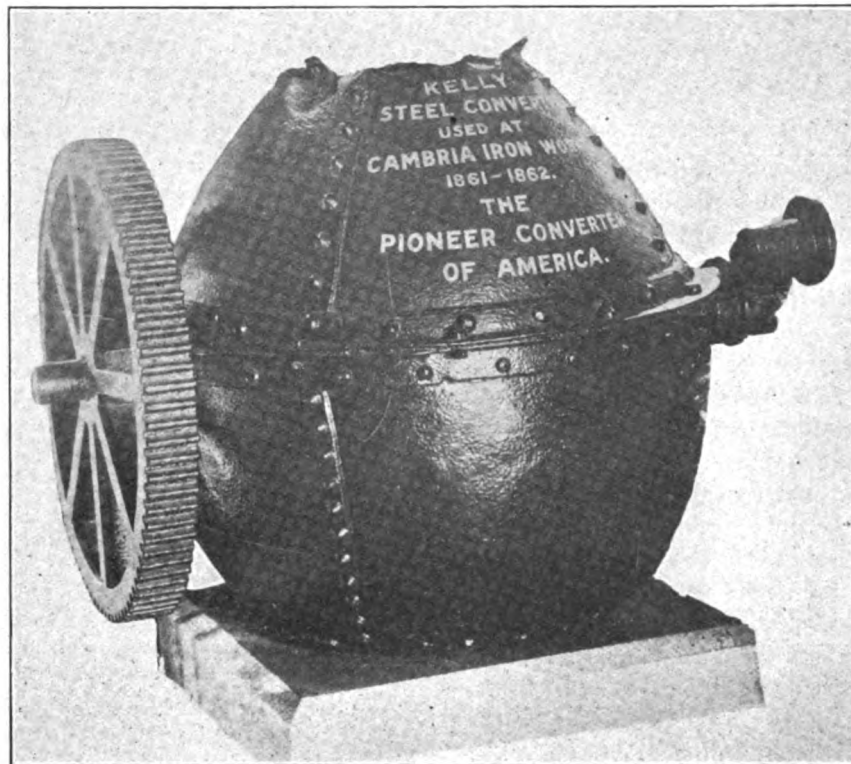
It is uncertain when the first "blister" steel was made in America, but we know that up to 1831 the total output had been made here. In 1860 we were still dependent on Europe for practically all of our steel requirements. The Bessemer process was then known, but as a dispute had arisen over its invention and an "interference" with the Bessemer patents had been granted to William Kelly, the process was not put into general use in this country until after 1860.

Credit Due Robert Mushet.

As a matter of fact, neither Bessemer nor Kelly is entitled to the honor of inventing the Bessemer steel

process. Kelly had, years before Bessemer began his experiments, conceived the idea of decarburizing iron by a blast of air, and had actually used the process in the making of iron which he used and sold in place of that produced in the refinery and run-out fires then employed. Sir Henry Bessemer conceived the same process and carried it out with a much more efficient mechanical appliance, which has been changed but little in general design to this day. But neither of these men were able to make steel. All they accomplished was to remove from pig iron the silicon and

carbon. Robert Mushet was the man who first found out how to make Bessemer steel by re-carburizing the iron after it had been blown in a converter. Kelly reaped very little benefit, also, but his name will always be regarded by Americans as the actual discoverer of the fundamental element in this great process, and the little converter which he had made at the Cambria iron works and used there with more or less success in 1857 and 1858 is an enduring monument to the spirit of discovery and the



The first converter used in the United States.

persistent effort which have made the steel business what it is.

The manufacture of Bessemer steel in this country did not attain any headway until 1867, but when it did finally start, its results were tremendous. It built the railroads of the United States, as well as most of our skyscrapers, bridges and ships. Yet in spite of this fact, it now seems destined to give place to an older and more expensive process, that of the open hearth; and this, in turn, will probably yield supremacy to the electric furnace, so rapid are the changes and so eager the industry to keep pace with modern knowledge and invention.

Development of Steel Fabrication.

Now less remarkable are the changes that 60 years have witnessed in the fabrication of iron and steel. When I first entered the business, the plant of my employer consisted of a small blast furnace, a refinery forge or two, and a mill upon which we rolled iron bars for various purposes. After the pig iron had

been refined in the furnace, a process somewhat like that of puddling, it was rolled into muck bar. This was then made up into bundles, reheated and rolled on a primitive form of bar mill. My first contribution to the efficiency of the plant was a plan to regulate the size of these bundles so that they would produce a bar of the size and length desired and thus eliminate excessive waste from scrap as each piece was rolled. It was recognized as a discovery and Mr. Ward complimented me highly.

The first bar iron was rolled in New England about 1825, and the first puddling in this country was done in 1835, both at the Boston iron works. The first successful American blast furnace of which there is a reliable record was built in the Ramapo mountains in 1800 or a short time prior to that date.

The first successful iron working plant was on the Hudson, at Cornwall, where some Cornish iron workers gathered soon after the middle of the eighteenth century. It was a simple bloomery and forge. In 1780 a forge at West Point, doubtless an outgrowth of the establishment at Storm King Mountain, produced a great chain which was stretched across the Hudson to prevent the British gunboats from passing

up that stream. That chain still holds the honor of being the largest ever forged, a fact which shows that our ancestors could rise to great efforts when inspired by patriotism, even as we are doing today.

The first steel rail rolled in America from American steel was made at the North Chicago rolling mill on May 24, 1865, under the direction of William F. Durfee, who had built the first successful Bessemer converter at Wyandotte. Steel made in this converter was used in rolling the rail referred to. I was attending a meeting of the American Iron and Steel Association in Chicago at the time and went with the party that visited the works to see the operation repeated the following day. Three rails were rolled on each occasion, and a part of one of them was cut off and sent to the meeting, where it naturally attracted much attention. By 1890 more than 19,000,000 tons of steel rails had been rolled in this country, practically all of them from Bessemer steel. In 1916, which, as you all know, was not a good year for the rail business, the output was 2,825,518 tons. Of this production in 1916 all except 440,092 tons were rolled from open hearth steel, showing the great development of that process during the intervening years.

Year Marks Progress in Industrial Safety

The Conservation of the Country's Human Resources is Being Given Increasing Attention—Reports From Steel Mills Explain Method of Conducting Safety Work.

Turning to our files I find a table, prepared by an eminent safety engineer, which may be of interest," writes Mr. Cameron. "Owing to the exigencies of war work and the hundred and one methods of recording data in the plants affiliated with the National Safety Council, the compilation will be of interest to the readers of THE BLAST FURNACE AND STEEL PLANT. The table follows:

Accident frequency per 100 employees for seven large iron and steel plants for the years 1916 and 1917 will give a fairly accurate estimate of the progress in the work of accident prevention:

Total No. of men employed	Year	Total injured	Rate per 100
37,049	1916	12,951	34.9
45,945	1917	13,104	28.5

The decrease you will observe, is a remarkable one.

Due allowance must be given for the large number of "green" men employed and the liability to accident of such employees, so a further qualification of the above figures should be noted.

Severity of accidents decreased in 1917, as compared with 1916, as follows:

	Days
Time lost per accident, 1916.....	7.3
Time lost per accident, 1917.....	6.5

The year, 1917, war conditions considered, is well worthy of note as a year of remarkable accomplishment.

It will be of more interest, however, to read the personal experiences of the foremost safety men in the movement, rather than tables of figures regarding the progress of the work, because the crux of the whole movement lies in the personality of the leaders and the efficiency of their methods, rather than in bald statements wherein men are computed merely as numerals and the work noted in parallel columns, interesting as these tables may be to the enthusiast in the work. Read what a few of our leaders in the council have to say on the subject:

There are four "M's" of business: "Men, Money, Materials and Methods," said Stephen W. Tener, man-

"What is the steel industry accomplishing in accident prevention work and what methods are being utilized to gain the desired ends?" THE BLAST FURNACE AND STEEL PLANT forwarded the above request to W. H. Cameron, general manager of the National Safety Council, and received the following interesting summary of activities and methods.

ager of the accident and pension department, American Steel & Wire Co.

"It has often been said that a child to grow up to be a worthy man or woman should be very careful in the choice of her grandparents; and the education of a foreman, as I see it, begins far back in the history of the company with which he is identified.

"Lives are saved and accidents prevented—and this is being accomplished by the application of common-sense methods, teaching the foremen safe methods and safe practices, and, through them, drilling the workmen in man-saving operations.

"Secure the coöperation of the foremen and half the battle is won. In this manner, together with careful safeguarding of all moving machinery and 'good house-keeping' in the plant, we have decreased our accident record 60 per cent in the American Steel & Wire Co.," said Mr. Tener.

"When we have an accident in our plant we hold a trial—an amicable trial—in the mill. An accident has occurred and we want to find who was to blame. A jury is impaneled and witnesses are brought in. They are questioned and their answers recorded. The last question asked every witness is: 'Have you anything to suggest to prevent the recurrence of a similar accident? Speak freely.' Then the verdict is brought in. We try to fasten the blame directly on some person, or indirectly on some person or object.

"These are the questions: 'What happened? Who is directly to blame? Who is indirectly to blame?' Occasionally the jury decides to lay a man off a day. One of these jury's verdict suggested a unique penalty. The guilty man was sentenced to make a safety address to all his associates—it was one of the very best verdicts we ever had. The man said: 'I will do it! I caused the accident, and I will do it!' We had that man's interests ever afterward. That is the answer to the question as to how we prevent accidents," said Mr. Tener.

"The record of the Illinois Steel Company speaks for itself," said T. H. McKenney, director of safety of the South Works of that company, "and we pursued much the same course in accomplishing results. Early in the year we held a meeting of executives to discuss ways and means whereby we might reduce our accidents. We came to the conclusion that we had to get closer coöperation from our foremen and sub-foremen. Accordingly, we called a meeting of our foremen and sub-foremen, leaving out the superintendent of the various departments. They all wanted to get in on it, but we did not let them.

"At a meeting the general superintendents and assistant general superintendents were asked for their coöperation and close attention at all times to get the undivided attention of the foremen and sub-foremen to bring about a reduction of accidents; in fact, they were told at that meeting that a reduction must be brought about—that the superintendents would be held responsible; the superintendents would hold the general fore-

men responsible, and the general foremen the sub-foremen. Therefore it behooved everybody to get on the job. The campaign was a success. We have had, and are now showing, a 57 per cent reduction in accidents over last—it is the best year the South Chicago works has ever had."

The Inland Steel Company, under the able direction of J. C. Smith, its safety director, gives gold watches to its foremen to improve its safety record. How the plan works is explained by Mr. Smith:

"We have one plant employing about 5,500 men, with 17 or 18 operating departments. A 'bogey' is established for each department, based upon its previous record, which gives them a certain percentage with which they have to work in order to get in a class showing a decrease in the percentage of accidents, as compared with their previous year. The departments showing the biggest decreases are the ones that get the watches. We donate 10 watches each month. No one department gets over one watch a month, after they have already won prizes.

"The superintendent, in order to encourage a certain foreman to take an interest in accident prevention during the next month, goes to him and says: 'Mike, if we win the watch this month, you are the man who will get it. It is up to you to get busy and prevent accidents.' Mike has to do it, or else he loses his turn, and he has to wait until all the other foremen have won.

"One department of our departments has nearly a whole year's record without a single accident. Several other departments have nearly a 100 per cent record each month, and I believe in all departments of the plant our system has stimulated a great deal of interest on the part of the foremen. Personally, I see no objection to giving prizes, because it is the same principle as giving a bonus for increased production. The foremen are simply stimulated to give additional attention to a certain part of their work for which they receive a prize for accomplishing certain results."

The United States is at war and the problem of protecting the life of the industrial soldier in the shops was discussed, and the subject turned to government plants.

"In conducting our educational work, we started, just as you do in all your shops, at the head, and worked all the way down," said Albert Regula, safety engineer of the Brooklyn Navy Yard. "We started with our industrial manager by having a lecture given to him, a lecture in which the audience was one man—the industrial manager. Before we were through we convinced him that the safety effort in our establishment was worth while. From the industrial manager we went to the heads of the various departments of machinery and public work. We convinced them. There, again, it was a one-man audience.

"From the heads of departments we went directly to what would correspond to your superintendents or general foremen—we call them quarter-men. Again we gave the same type of lecture. We compared the ex-

periences of industrial corporations with the accident frequency at the yard. Then we got to our foremen, again hewing over the same ground. When we were through with the foremen we went directly to the workmen, going over the same ground, and asked their coöperation in safety work. We showed them what had been accomplished elsewhere, told them the attitude of the officials, and showed them how much concern the officials were taking in safety work. The men have taken the work to heart and are endeavoring to do everything possible to prevent accidents. We emphasize that we wanted to give each of them an active part in safety work; we could not do it alone; the officials could not do it, and unless we could get their coöperation and make each feel he was a committee of one, all working together, we would get nowhere. Then we told them what we had in mind with respect to foremen and the safety committees. We told them what we expected each man to do, and here is the result: The men asked to be placed on committees.

"In several of our shops, after outlining our workmen's committees, the men came to us and asked to be placed on safety committees. They were interested and wanted to give us more of their coöperation. They knew of conditions they thought might be remedied. They would not, at that time, tell us what they were, but if we would put them on a safety committee and give them a chance to show us how much they were in earnest in safety work, why, they were with us. In the Brooklyn yard we have the industrial manager and men all the way down to 200 apprentice boys in our industrial school—all pushing and talking safety."

"Perhaps a side light on the work would be interesting," wrote a safety engineer in answer to an inquiry of General Manager Cameron. "Of our plant force of approximately 30,000 men 97.8 per cent subscribed for Liberty bonds and the total of their holdings exceeds \$2,000,000. For the entire corporation 94.4 per cent of the men subscribed and they are proud possessors of \$5,777,000 worth of the bonds."

"We are educating the workman to use his eyes—instead of keeping them on the floor or on the clock—to see whether a certain ladder is safe," said R. G. Griswold, of the Hopewell works, of the E. I. DuPont de Nemours & Co. "Does the foreman know that bolts are getting weak and are liable to cause an accident? Are they weak? Are the walkways safe? Does he test them himself? Does he go to the top of the ladderways and see the places where men have to go frequently. Does he know they are safe? Does he see that all wiring in his plant is insulated in such a way that men will not come in contact with some bare portion and fall to the floor below? Does he see to every operating condition in the building? He is supposed to be of superior mentality, as he is supposed to be the hirer of the men working under him. He should spend a portion of his time, at least, in seeing that every condition in the building that has contributed to accidents is now all right. I do not

believe that hammering and discipline and laying-off and discharging and giving prizes is going to be of any great effect, because it is not permanent. We must get the humanitarian spirit of the safety movement into the heart of every man. We are getting results, too."

Carl L. Smith, of the Commonwealth Steel Company, said: "Cranes are considered very dangerous, about the worst hazard in the mill. We have a safety inspector who has not had an accident on his cranes in 21 years. Of course, all our departments are not equally successful, but we are getting excellent results from our accident prevention work."

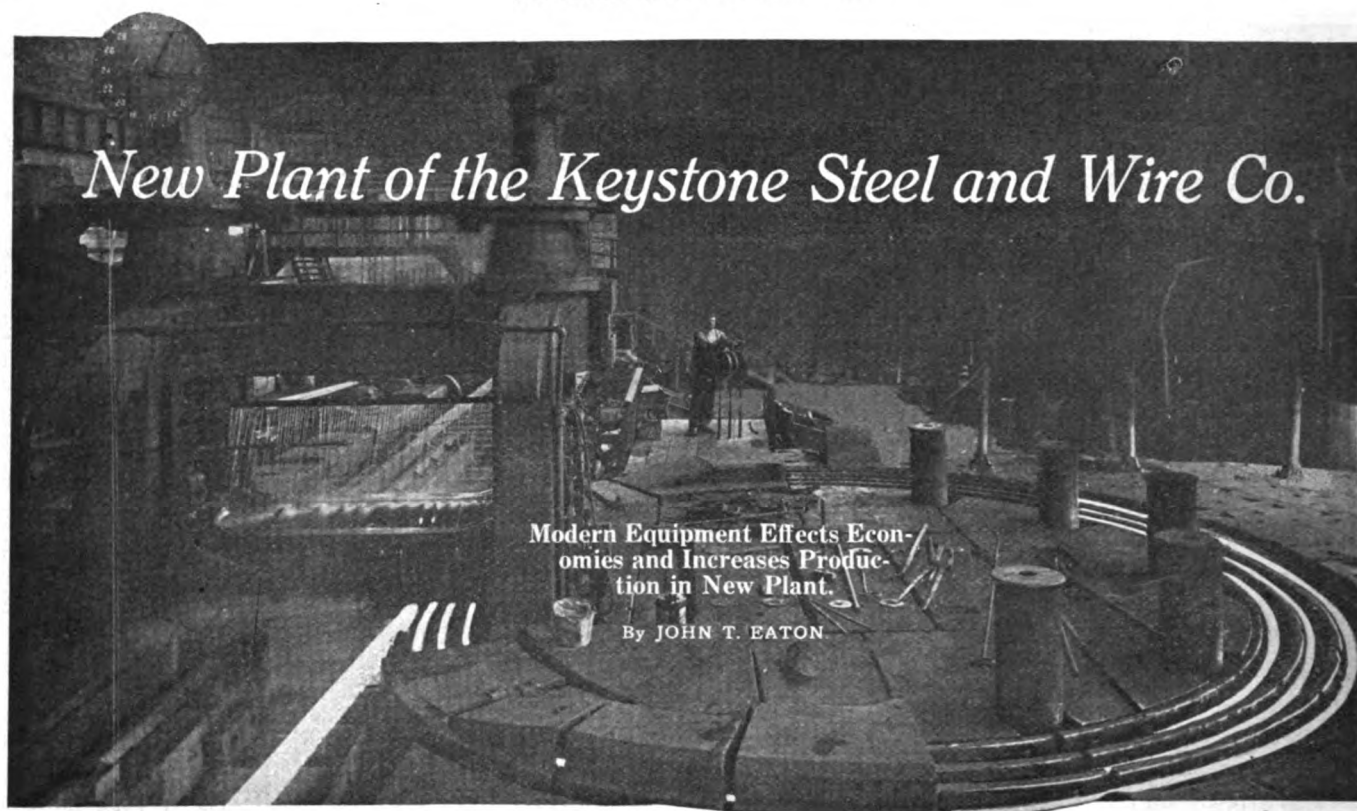
Dr. Shoudy, of the Bethlehem Steel Company, touched on a somewhat different plan of accident prevention work. He said: "Men must have proper living conditions, proper food, proper clothing, and proper relaxation and recreation because all these affect health. If they do not have proper food and water and good milk for themselves and their families, what happens? Accidents!"

J. S. Herbert, of the Cambria Steel Company, contributed the following: "At Cambria, about four years ago, we started a safety movement and we began to dig for the causes of the accidents. We had one of the oldest industrial hospitals in the world, and we wanted to eliminate its effect. Following various lines of research we secured the information desired. Our accident record began to go down hill. Some of us felt, figuratively speaking, it was like the snowball—we had gotten it started and it would roll itself. That was during 1913. In the latter part of 1914 our accidents took a jump. Some of us began to jog the general manager, so we could find out why. Finally we went over our records for the three years previous and discovered several interesting things. Then we studied the record for a single year. The result of our investigation showed that the new man, a man employed under 30 days being relatively a new man, was 12 times as liable to injury in an iron and steel plant than the man who had been employed for over 30 days. Those are actual figures."

"As a result we went after the cause and we felt that education of the new man was necessary. Our new-man line has gone up. I believe our weekly record, at the present time, shows the minimum number of new men employed during the history of the company, but the accident line has gone down. We have regained all that we lost during the four or five months we were trying to find out why; not only have we regained that, but we are again on the downward trend. Outside of the months of June, July and August, for three years we have never failed in any one month to break the previous best monthly accident record."

"That 12 times as liable to injury may not sound very much, but if you are running in a lot of new men you will find it counts up. Some of the other figures show that this year our new-man accident hazard has been cut in half. In other works, the new man is six

(Continued on page 52.)



New Plant of the Keystone Steel and Wire Co.

Modern Equipment Effects Economies and Increases Production in New Plant.

By JOHN T. EATON

The Keystone Steel & Wire Co., of Peoria, Ill., was originally engaged in the production of woven wire fencing. Recent industrial and trade conditions have made it expedient for the company to erect a plant for the production of its raw materials, and now the Keystone Steel & Wire Co. places ingots, billets, rods, wire, fencing, and other wire products upon the market. The woven wire fencing remains the most important of its products.

The Keystone company originated 28 years ago, when Peter Sommer started to manufacture wire fence on his farm near Tremont, Ill. A small plant was erected shortly after at Tremont, to which several additions were made, and later the concern moved to Peoria, where conditions were more favorable to manufacturing and shipping. Here the company soon outgrew the available space and the present plant, for working rods into fencing, was built at South Bartonville, a suburb of Peoria. During the past year the plant under consideration was built at Steeldale and put into operation. The new plant consists of an

open hearth department, blooming mill, and rod mills. Fig. 1 shows a general layout of the entire plant, which has been laid out with sufficient space to provide for future additions to the various departments.

Handling of Raw Materials.

The storage yards, at the extreme right of the layout afford ample storage space for a plant of this size and are completely equipped for handling the materials with facility and speed. A gantry crane, with lifting magnets, operating upon tracks having a span of 70 feet, runs along a distance of 700 feet, practically the entire length of the yard. The track and switching facilities are complete and conveniently arranged. It may be interesting to note that this plant uses pig iron from the Birmingham district. Practically all of it is transported a distance of 680 miles on barges by water, down the Tennessee and Ohio rivers, and up the Mississippi and Illinois rivers to Peoria.

Fig. 2 shows the rather unique method of transporting the pig iron. The pigs are shown being un-

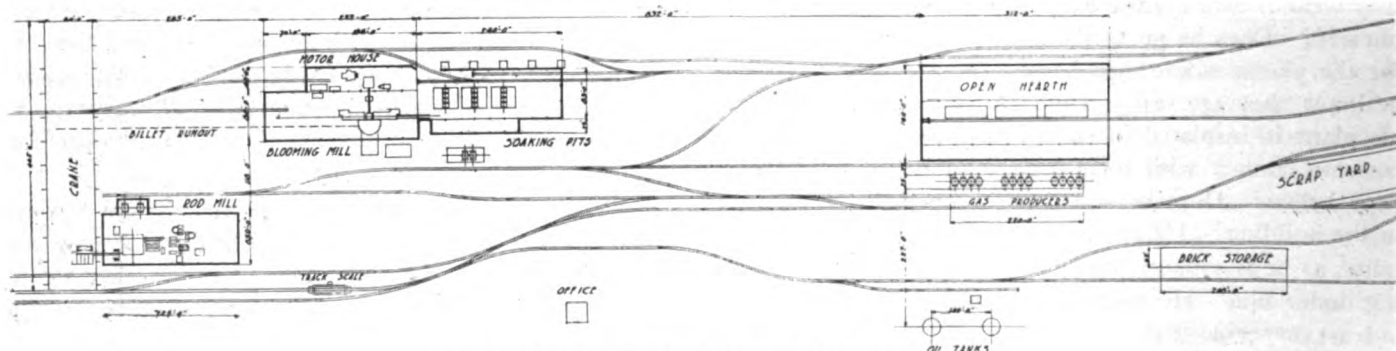


Fig. 1—Showing general layout of entire plant.

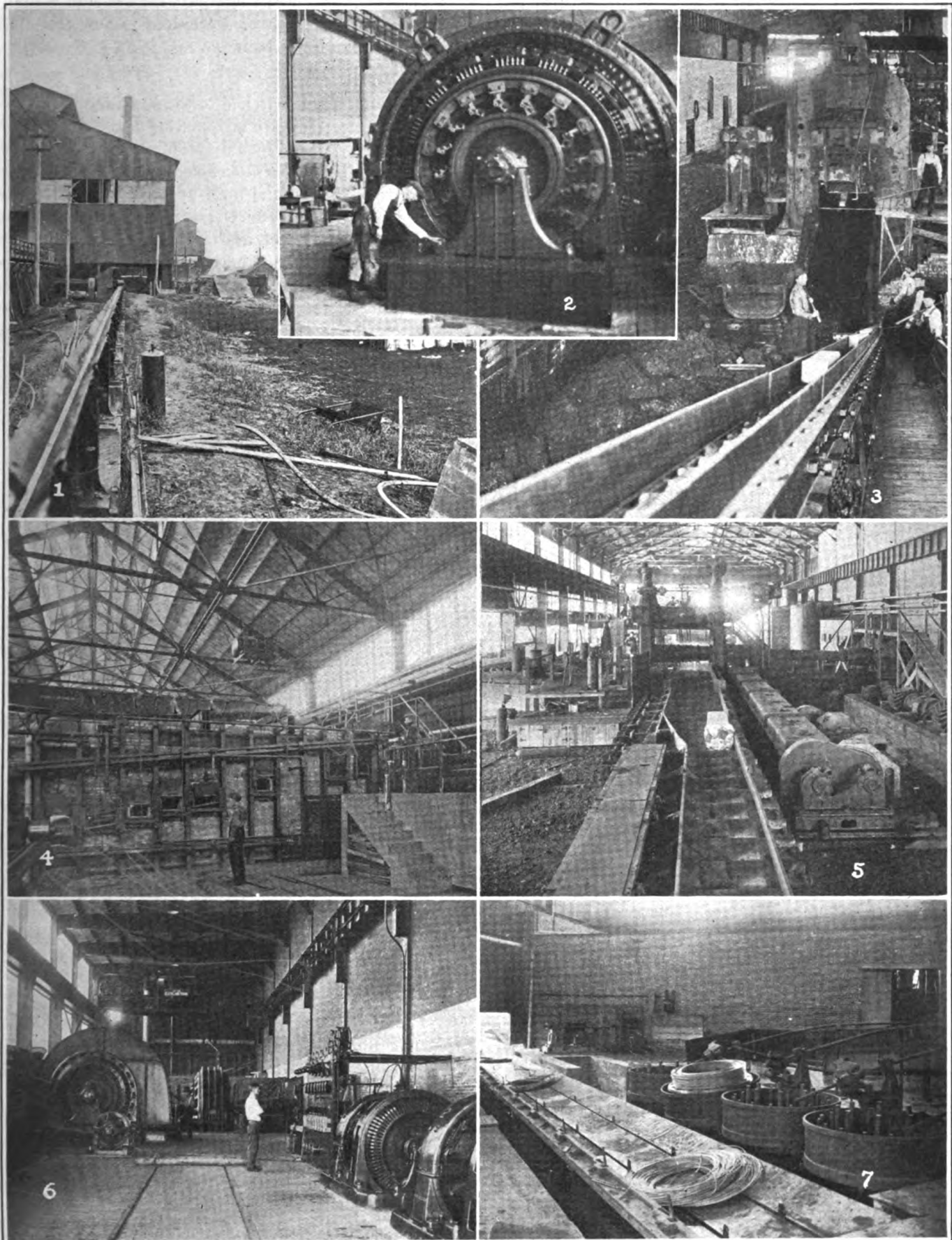


Fig. 1—13½-inch billet leaving blooming mill on the way to the shear house. Fig. 2—One of the motors for driving the fly-wheel of the blooming mill. Fig. 3—Cutting 5 x 5 commercial billets. Fig. 4—Part of rod mill furnace where billets are reheated. Fig. 5—Ingot passing over rolls to the blooming mills in the background. Fig. 6—Part of the power station, showing motor driving flywheel of blooming mill at the left. Fig. 7—Coiling finished rods.

loaded from the barges on to freight cars by means of lifting magnets.

Open Hearth Department.

The furnace equipment consists of three 75-ton stationary open hearth furnaces operating on producer gas and oil with a cold charge of about 25 per cent pig iron and 75 per cent scrap. The furnaces were designed by Julian Kennedy, and built by the Stone & Webster Engineering Co.

In addition to the water cooling of the doors there are several applications of water cooling on the furnaces. The gas port and uptakes are cooled by means of pipes laid in the brick work. The skewbacks of the roofs are water cooled, and slag line coolers have been installed. The doors are manipulated by hydraulic cylinders. Each furnace is provided with a

is well lighted. On the tapping side a row of windows extend the full length of the building a few feet above the top of the ingot molds.

Soaking Pits.

The ingots are switched to the soaking pits by locomotive, where they are stripped by a 100-ton Alliance stripper and charged by a five-ton pit crane of the same make. The three four-hole soaking pits were designed by Julian Kennedy and built by the Stone & Webster Engineering Co. Producer gas is the fuel used. Each hole is 6 feet $\times$ 8 feet, and is capable of holding from six to eight ingots. There are two self-supporting steel stacks and one concrete stack 5 feet 6 inches inside diameter and 125 feet high. The reversing valves for the gas are of the Foerster type, and for the air Siemens type is used. The pit covers are operated by

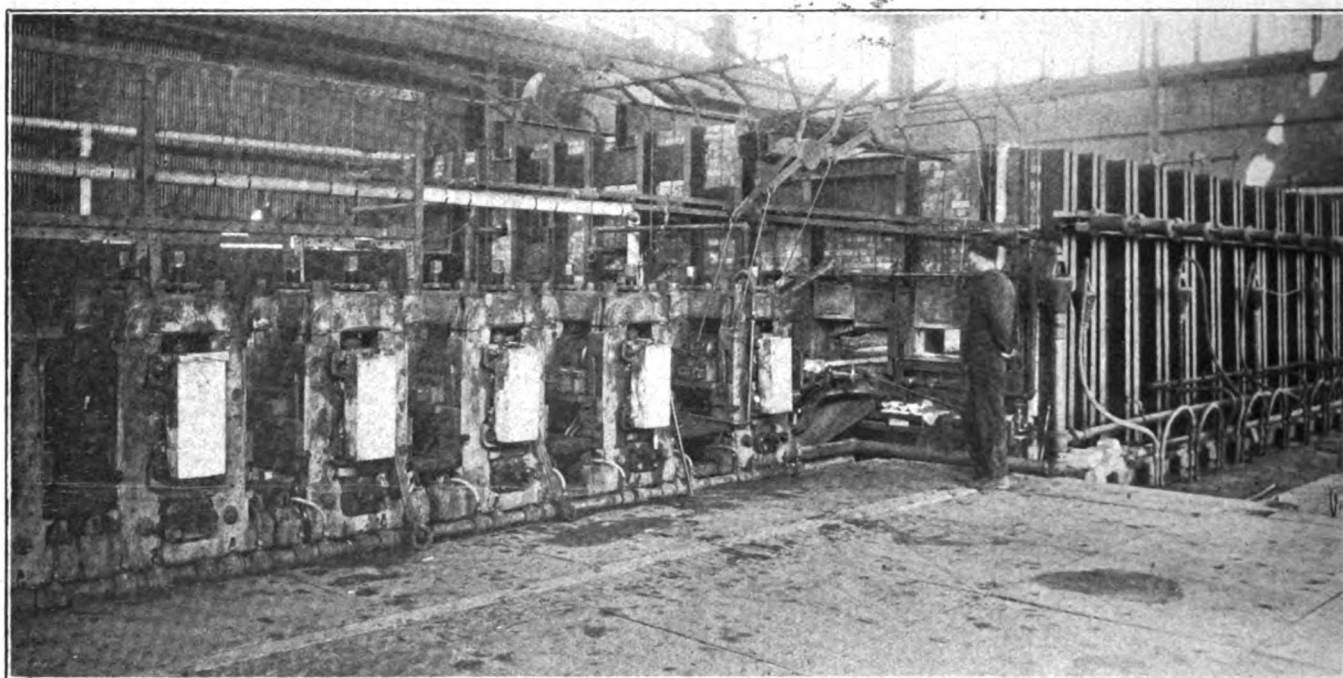


Fig. 8—Billet heating furnace and roughing rolls.

jib crane to handle the runner. There are four 20-ton Duff gas producers for each furnace. The stacks are 5 feet 6 inches inside diameter and 150 feet high. Two of them are self-supporting steel stacks and the third is concrete. Two of the furnaces are reversed by means of Blair valves. The third is equipped with Knox valves. Waste heat from the furnaces is utilized by three 500 hp. Keeler water tube boilers. The bypass from the flue to the boiler is 5 feet wide and 6 inches high. The induced draft is furnished by turbine driven fans.

The charger has five tons capacity and is of the high type. The ladle crane is rated at 125 tons. Both are products of the Alliance Machine Co. The ingots are top poured, weigh about 4,500 pounds and are 16 inches $\times$ 18 inches in cross section, which is the size suitable for the type of blooming mill rolls used. The open hearth building is provided with ample space and

hydraulic cylinders. The ingots enter the soaking pit building on one side of the pits and are placed on the approach table to the blooming mill on the opposite side.

Blooming Mill.

The blooming mill is designed to reduce the 16 $\times$ 18-inch ingots down to 1 $\frac{3}{4}$ -inch square billets. This is accomplished by means of a repeater table and special passes on one end of the rolls, the complete details of which are explained below. The mill is a 35-inch electric-driven reversing blooming mill, built by the Wheeling Mold & Foundry Co. It is driven through 18-inch lead spindles, and double helical pinions of 40-inch face, by a General Electric reversing motor rated at 2,000 hp. continuously and 10,000 hp. momentarily, the power for which is supplied by a motor generator set with a 50-ton flywheel.

The approach and run-out tables screw down, manipulators and side guards are each operated by an 80 hp. motor. The pulpit is located over the run-out side of the mill, where the individual controllers for each unit are installed. The entire electrical equipment of the blooming mill, consisting of the main driving set, manipulating drives, controllers, etc., was furnished by the General Electric Company.

Fig. 10 shows the details of the blooming mill rolls. The operation is as follows: The 16×18 -inch ingot is first reduced to a 4×4 -inch square in the passes marked 1, 2, 3, 4 in the illustration in the usual manner and run out to the shear at the end of the mill table, where the ends are cut off even, the billet returning to the mill. It enters the repeater at one of the oval passes marked 5 and comes out the approach side

Three sets of horizontal pinch rolls move the billet in the trough conveyor and serve as a feeding device to the billet shear located at the end of the trough, where they are cut hot into 30-foot lengths and delivered onto a 16×30 -foot cooling bed. After cooling, the billets are handled and transported to the rod mill by an overhead crane. The shearing equipment consists of a 100-ton and a 340-ton hydraulic shear made by the R. D. Wood Company.

Billet Heating Furnace.

The billets for the rod mill are heated in a Morgan suspended roof type continuous heating furnace. The hearth slopes downward in the direction of the movement of the billets and has an effective area 24×30 feet. The top is made up of four arches supported at the two ends of the furnace and suspended from three

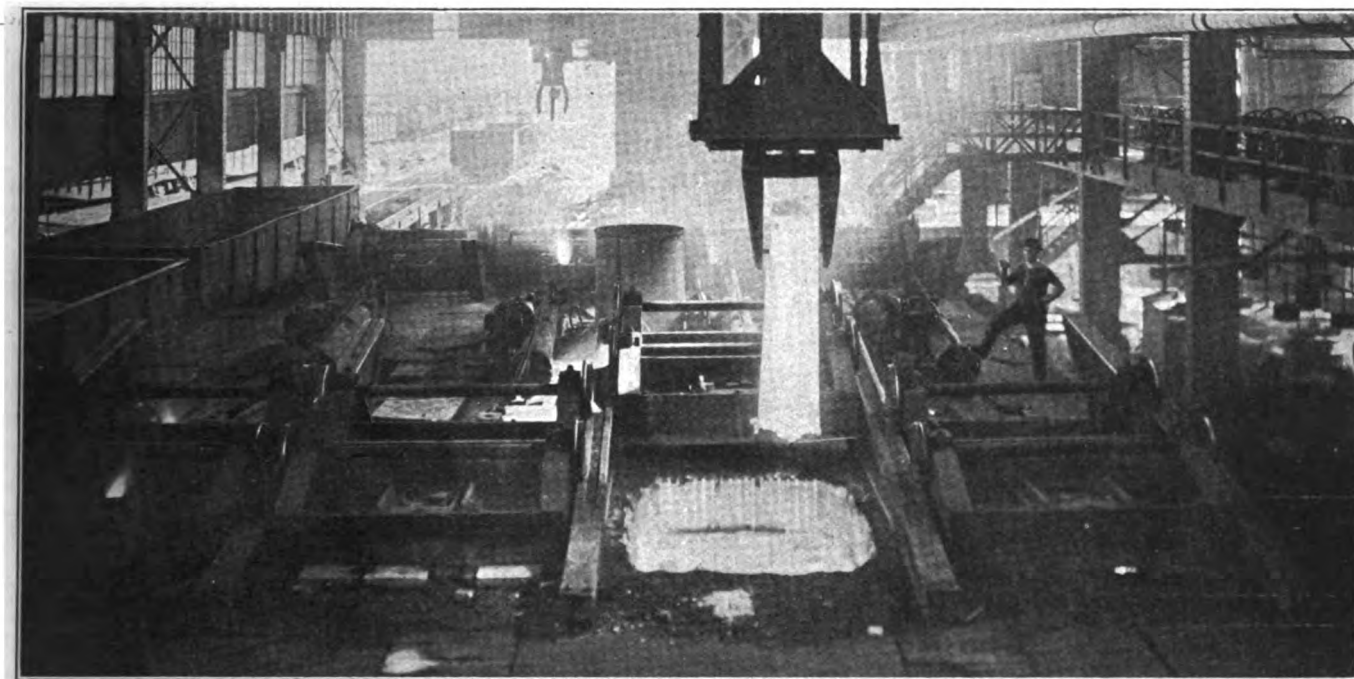


Fig. 9—Showing ingot being lifted from soaking pit.

of the mill into a trough which guides it around the outside housing in a 30-foot circle and into one of the square passes marked 6, from which it comes out and is guided around to passes 7 and 8 successively in the same manner, making three complete loops around the outside housing and filling four passes at one time. Each loop is picked out of the repeater trough on to the cast iron floor by a hand-operated kick-out mechanism as soon as the loop is completed, and the difference between the speed of leaving and entering successive passes causes the length of the loop to exceed that length of the trough. The kick-out operating levers may be seen in the illustration at the headline of this article.

From pass 8 the billet is guided under the three preceding loops, around and out of the building in the direction of the shears in a V-shaped trough conveyor 460 feet long, which the finished billet almost fills.

double I-beam girders at intermediate points. The walls are very heavily stayed with I-beams and the tie rods are held in tension by large compressed helical springs under the nuts. The only applications of water cooling are at the doors, valves and the skids upon which the billets slide inside of the furnace.

The furnace is fired by gas from a Morgan continuous gas machine. The air is forced in by a motor-driven fan on top of the furnace and preheated before uniting with the gas by the recuperative principle in which the air is caused to go through passages built around the hot outgoing gases. The draft is furnished by a steel stack having an inside diameter of 4 feet 6 inches, and 80 feet high.

The billets are charged into the furnace lengthwise from a charging conveyor and are pushed down the inclined hearth by means of a steam-actuated pusher. At the bottom of the hearth the heated bil-

lets are pushed directly into the first pass of the rod mill roughing stands.

Rod Mills.

The rod mill is also a product of the Morgan Construction Company. It consists of 16 stands; six roughing mills, which are shown in Fig. 8, four intermediate and six finishing mills. The roughing and intermediate stands are grouped together and are driven by a 2,000 hp. ac. motor. The finishing stands are driven by a 1,000 hp. ac. motor. The speed of the motors is regulated by two Scherbius regulating sets. Repeaters are located between the tenth and eleventh and between the twelfth and thirteenth stands, to allow for some variation in speed between the two motors. After passing through the roughing and intermediate rolls the rod passes around both repeaters, through the finishing rolls and out through guiding tubes to the coiling reels at a rate of

heat boilers on the open hearth furnaces the power is obtained from the city supply and comes into the plant at 13,000 volts. This is transformed to 2,300 and 440 volts for the various purposes about the plant. Two 500 kw motor generator sets furnish the dc power at 230 volts.

The water supply is drawn from the Illinois River. General water supply at 60 pounds pressure is supplied to all departments by motor and turbine-driven centrifugal pumps.

The hydraulic apparatus operates at a pressure of 500 pounds per square inch. The pumps, a duplicate set of motor-driven triplex Worthington pumps of 125 hp, and the accumulators are located in the blooming mill building, and the hydraulic power is piped from there to the different places of application over the plant.

This is one of the number of moderate-sized plants

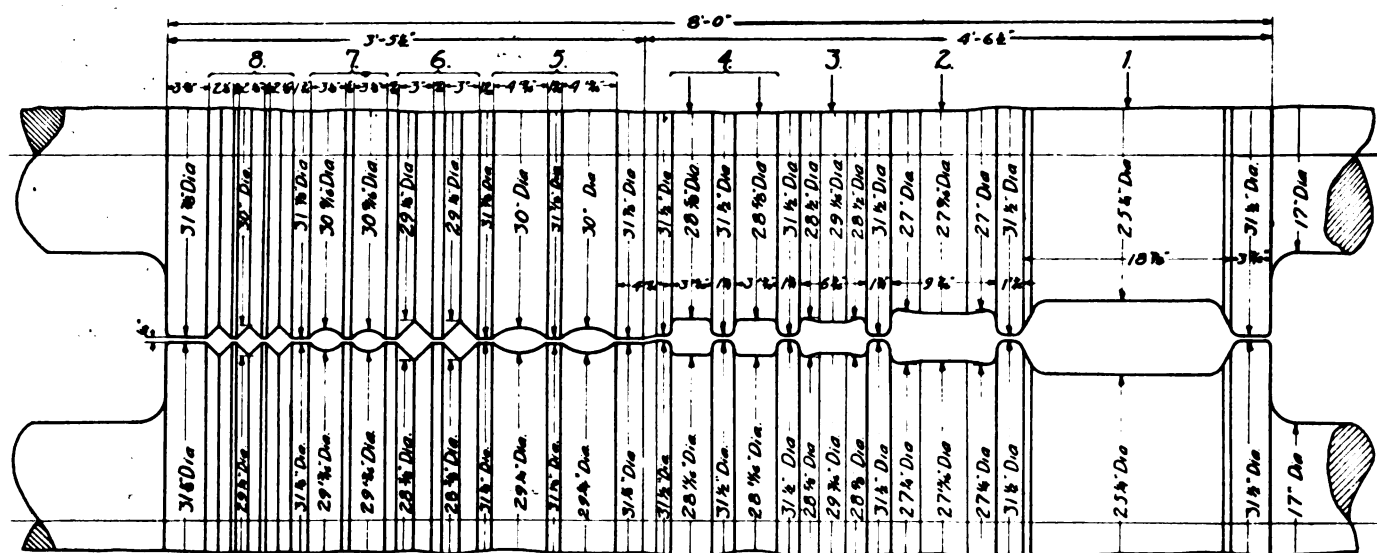


Fig. 10—Detail of rolls on blooming mill.

about 30 miles per hour. This is a double strand mill, so that two rods are constantly passing through in parallel.

The rod reels are of the pouring type, electrically driven. The operator dumps the finished bundles on the conveyor which is of the muffle type and serves to anneal the rods. From the conveyor the bundles are loaded on to rod trucks, weighed, and hauled away either to be stored or shipped or carried to the wire drawing plant at South Bartonville, by a company-owned narrow gauge railway.

General Equipment.

The buildings are all of steel and corrugated iron and aggregate an area of about 155,000 square feet. Lighting and ventilation is given every possible consideration by placing two and in some places three continuous rows of windows, pivoted on vertical axes about the centers of the sashes, in every building.

With the exception of that obtained from the waste

that have been built during the past two or three years as a result of the conditions that have been in effect in the iron and steel industry, and the thriving condition of some of the dependent industries. These plants have practically all been built according to the most up-to-date design and practice, and their effect has been to accelerate the progress of improvement in the manufacture of iron and steel. This plant in particular is filled with examples of the latest development in method and equipment, and the whole concern is an example of the modern type of highly organized and highly efficient manufacture.

A canal a mile long, 100 feet wide, and 12 feet deep connects the plant with the Illinois river and provides a convenient outlet for a considerable volume of shipments, both in and out of the plant. It has complete dock and track facilities, with complete loading and unloading equipment. Shipments of pig iron, scrap iron and other materials are handled by this canal.

Flywheels for Rolling Mill Application

Investigations Showing Requirements of Flywheel in Rolling Steel—Speed, Losses and Location of Flywheels Considered—
Compensation of Peak Load Without Overloading Motor.

By G. E. STOLTZ.

Westinghouse Electric & Manufacturing Co.



G. E. STOLTZ.

IN order to definitely and accurately analyze the requirements of the power required to roll steel it is as essential to carefully study the question of flywheel capacity as it is to determine the application of motors.

The intermittent character of the rolling mill load generally makes it necessary to include flywheel capacity to equalize the power requirements and avoid heavy momentary overloads on the driving unit, as well as on the generating station. On some applications, the magnitude of the peak loads are not so great, but it has been found that a small amount of flywheel capacity protects the electrical equipment from shocks obtained on the mill. Where there is a demand for a flywheel to equalize sustained peaks, the use of the proper flywheel effect permits the installation of driving and generating equipment designed to carry a load of practically a constant character. Better overall economy is obtained, although the friction loss of the flywheel is added. There are a number of other advantages from an operating point of view which are generally appreciated but are hard to capitalize.

Energy of a Moving Mass.

When considering the power required to roll steel, the length of a pass is usually measured in seconds, and the size of the driving equipment is rated in horsepower. A conception of the values which are used may be obtained from the following equation:

$$\text{Hp. seconds} = \frac{W.V.^2}{64.4} \times \frac{1}{550} \\ = \frac{W.V.^2}{35,400}$$

W = weight of flywheel in lbs.

V = velocity of moving body in ft. per second.

It is therefore apparent that the energy in a moving mass depends on two conditions, its weight and velocity, and since its energy varies as the square of

its velocity, it is important to use as great a velocity as is practicable.

The total flywheel effect of a body rotating about an axis is equal to the sum of the products obtained by multiplying every elementary mass by the square of its velocity. The equivalent of this is found by using the total weight and the peripheral velocity at the radius of gyration. The radius of gyration of a plate wheel is .707 of the outside radius. This value for a spoke wheel depends upon the displacement of its metal, but for the practical purposes, it is satisfactory to use .8 of the outside radius for wheels of usual design. In these calculations the weight of the shaft is not included.

A curve showing the relation between speed of a wheel and kinetic energy measured in horsepower seconds is illustrated in Fig. 1. It should be noted how rapidly the stored energy increases in the wheel at the higher speeds. The diameter of this particular wheel is 12 feet, its peripheral velocity being 19,400 feet per minute, or 3.7 miles per minute. In this particular case the equipment was designed to operate on a basis of 20 per cent speed drop. The energy which is therefore available for flywheel effect is the difference between that stored at 100 per cent and 80 per cent speed or 62,600 hp. seconds, which is 36 per cent of the total energy in the wheel at 100 per cent speed.

Location of Flywheel.

The flywheel should be placed as near the load as possible to avoid transmitting the peaks through apparatus which might otherwise carry only the average load. However, on some applications, such as sheet mills, it is not feasible, as the mill speed is too slow. If it were desired to properly equalize the load on an eight-stand mill with a flywheel operating on the mill shaft at 30 r.p.m., a wheel of 350 tons weight would be required. This, of course, is not practical and while on engine-driven mills a comparatively large engine may be used with a moderate sized wheel, still the engine does not fully compensate for lack of flywheel capacity, with a result that the speed drops considerably when peak loads are obtained. With electric drive, the motor is usually operating at about 240 r.p.m. and a herring-bone gear unit is provided to obtain the proper mill speed. The flywheel capacity is usually obtained by placing a wheel at each end of

Abstract of paper read before Pittsburgh section of A. I. S. E. E. meeting held December 15, 1917.

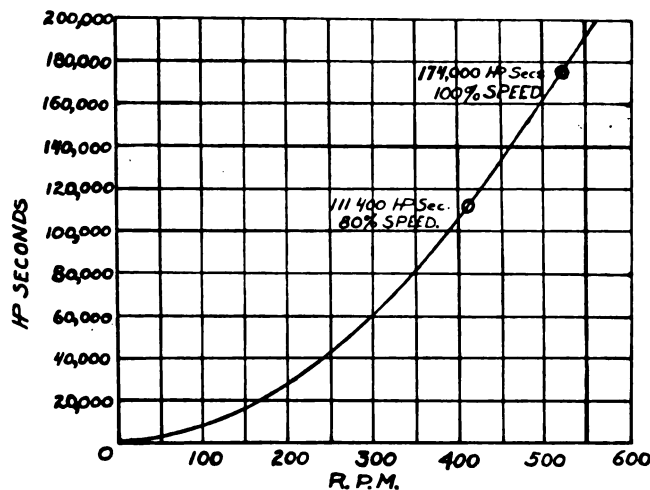


Fig. 1—Energy curve of flywheel set.

the pinion shaft. By doing this, the total weight of the wheels would be 30 tons to provide the same flywheel effect as would be obtained if a 350-ton wheel were placed on the mill shaft. This, of course, has the disadvantage of transmitting all the peaks through the gears, but is the practical solution for this type of drive. Where sheet-mill engines have been replaced by motors, with adequate flywheel effect, the monthly output is increased approximately 10 per cent. This is due to the elimination of periods when the mill is slowed down sufficiently to interfere with its operation.

Stand-By Losses of Flywheels.

The friction losses of a flywheel are due to bearing friction and windage. The wheels of slow-speed wheels is not of great importance, but on the higher speed wheels it is by far the greater factor. The large flywheel motor-generator sets used for reversing mills or hoists are usually built with a sheet-metal cover over the flywheel as a protective device. It also reduces the windage losses. Some conception of the magnitude of these losses can be obtained by noting the temperature rise of the sheet-metal cover. This heat is generated from the eddy currents and surface friction of the air between the flywheel and its cover.

A run-down curve was taken of a flywheel set which happened to be operating at 515 r.p.m. The weight of the plate wheel is 100,000 pounds and its diameter 12 feet. The kilowatt input of the driving motor was read immediately before the set was shut down, and as the breaker was opened readings were begun, to obtain the speed of the set at intervals of time while the wheel was allowed to drift to a standstill. The values given in Fig. 2 indicate the readings obtained. After subtracting the losses in the driving motor, it was found that the friction load was 126 hp. This is composed of bearing friction and windage of the wheel. The windage of a wheel varies as the square of its velocity, while the torque due to bearing friction is approximately constant as long as the oil film is not broken. Therefore, the main loss on a

slow-speed wheel is bearing friction and the run-down curve on such a wheel would be practically a straight line. Drawing a straight line tangent to the curve at 515 r.p.m., we find that the set would come to rest in 46 minutes if the torque, due to windage, did not decrease with the speed. During the time which elapsed between the eightieth and one hundredth minute, it will be noted that the curve is practically a straight line, indicating that after the set had reached a speed of 60 r.p.m., the windage became negligible. Drawing a straight-line tangent to this portion of the curve, we find the set would come to rest from 240 r.p.m. in 107 minutes, if bearing friction were the only retarding force. Since the slope of these two lines is proportional to the friction torque, and that of the first line, which is drawn from a point representing 515 r.p.m. on the vertical scale to a point representing 46 minutes on the horizontal scale, is due to the combination of windage and friction, while that on the other line is due entirely to bearing friction, it is possible to segregate these losses. The slope of the tangent 515 to 46 is proportional to the total friction of 126 hp., which is obtained at 515 r.p.m. This may be represented by the ratio of the ordinate divided by the abscissa:

$$\frac{515}{46} = 11.2$$

The slope of the tangent 240 to 107 is proportional to the bearing friction.

$$\frac{240}{107} = 2.24$$

$$\text{Bearing friction} = 126 \times \frac{2.24}{11.2} = 25.2 \text{ hp.}$$

Eighteen inch bearings were used on this set which gives a bearing velocity of 2,420 feet per minute. Usual-

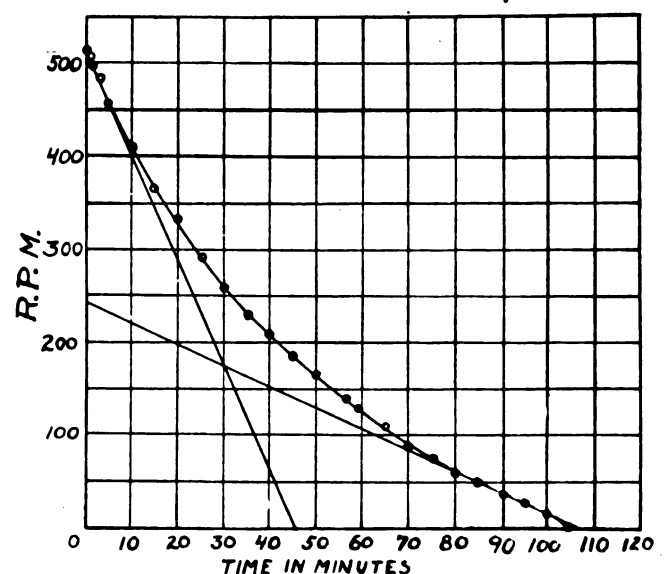


Fig. 2—Run-down curve of flywheel set showing variation in windage friction.

ly the variation of the coefficient of friction, due to change in speed, is negligible, but as this is a high-speed bearing, we would estimate the friction at 515 r.p.m. to be 20 per cent less.

$$25.2 \times .80 = 20.2 \text{ hp.}$$

Say 20 hp. bearing friction at 515 r.p.m.

$$126 - 20 = 106 \text{ hp. windage at 515 r.p.m.}$$

The correction for a variation of bearing coefficient of friction need not be considered on the slower speed wheels, particularly where the journal speed does not exceed 1,500 feet per minute.

It will be noted that the curve drops abruptly from one hundred and third to the one hundred and fifth minute. This is the point at which the journal loses its oil film and the coefficient of friction is greatly increased.

Energy of Rotating Parts.

From this curve in Fig. 2 it will also be possible to check our calculated figures of the energy in the rotating parts. At 515 r.p.m. we found the flywheel friction and windage to be 126 hp. If this friction torque were maintained, the set would come to rest in 46 minutes. Since the average speed of the set during this period is one-half of the initial speed, the average horsepower developed between 515 and zero would be 63; therefore, the total flywheel effect at 515 r.p.m. would be:

$$\begin{aligned} \text{Hp. seconds} &= 63 \times 46 \times 60 \\ &= 174,000 \text{ hp. seconds.} \end{aligned}$$

This energy varies as the square of the speed, as is shown by the curve in Fig. 1. At one-half this speed, the energy in the wheel would be one-fourth of 174,000 or 43,500 hp. seconds.

Selection of Flywheel.

The selection of the proper flywheel for a mill-drive can often be calculated to a fairly close degree if the operating conditions are properly represented. These conditions can be obtained by comparing the mill in question with a number of similar mills on which an analysis has been made of power requirements. However, on some mills, it is practically impossible to make any calculations, in which case it is necessary to depend entirely on tests made on a number of mills of the same type.

Unless these tests are used as a guide, it is easy

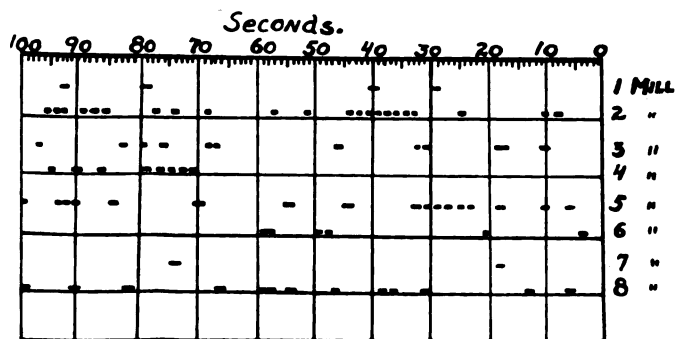


Fig. 3—Pass record showing time metal was in rolls of 8-stand sheet mill.

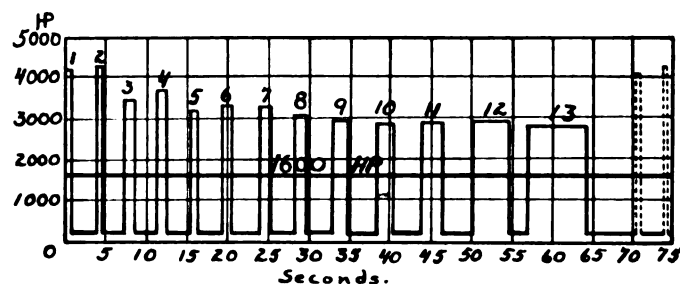


Fig. 4—Mill load on small blooming mill peaks above 1,600 hp to be taken by flywheel.

FLYWHEEL ENERGY EXPRESSED IN HP SECS.

Pass	Flywheel load during pass	Accumulated flywheel debt at end of pass	Restored during interval	Flywheel debt at end of interval
1	1,670	2,370	2,370	....
2	2,050	2,050	2,050	....
3	1,620	1,620	1,620	....
4	1,940	1,940	1,940	....
5	1,800	1,800	1,800	....
6	2,180	2,180	2,180	....
7	2,450	2,450	2,450	....
8	2,520	2,520	2,520	....
9	2,870	2,870	2,870	....
10	3,110	3,110	3,110	....
11	4,570	4,570	4,200	370
12	5,780	6,150	4,200	1,950
13	7,150	9,100	8,400	700

to assume conditions which will not be obtained in actual practice. For instance; tests were made on a motor driving eight sheet mills. Graphic charts were obtained, the total length of each test being 30 minutes. A portion of one of these charts is shown in Fig. 3. The dots at the edge of the sheet indicate the time in seconds and the dashes in the eight different rows represent the time the metal is in the rolls. Each row represents the operation of a particular mill. Although a large number of these charts were obtained over a long period of time, it was surprising to find that not more than four stands out of the eight had metal in the rolls at the same time. On this particular chart, the following results were obtained:

	Per cent
Time during which no metal was in the rolls ...	26.6
Time during which metal was in one stand only..	39.1
Time during which metal was in two stands only..	26.3
Time during which metal was in three stands only..	7.36
Time during which metal was in four stands only..	.64

Without making such investigation, it might be thought that it would be necessary to provide flywheel effect to take a peak obtained from metal in five or six stands at one time, when in fact only three stands need be considered.

On applications of this kind, it is necessary to test similar mills having a different amount of flywheel effect in order to determine which ones have the proper amount. No method of estimating would be of any practical value.

In most cases the load is not so complicated and it is a simple matter to approximate the load which will be obtained.

Fig. 4 is an estimated mill load on a three-high 28-inch blooming mill operating at 70 r.p.m. The average load is found to be 1,284 hp. This includes the friction load of the mill and is the value on which the rating of the motor should be based. In preparing a curve like this, no difficulty will be met in deter-

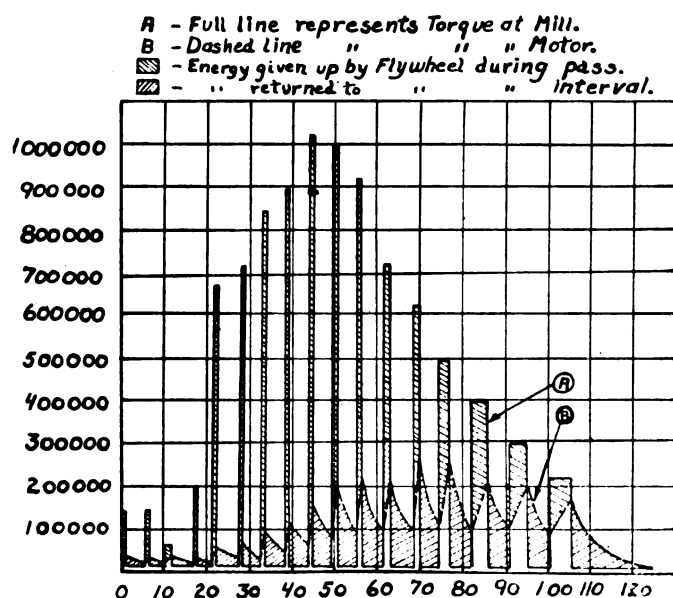


Fig. 5—Curve showing relation of motor load and flywheel load on 3-high plate mill with fixed resistance in motor secondary.

mining the length of the passes, as the size and speed of the mill is known.

Observations were made to determine the interval between passes and it was found that under the most favorable conditions, they averaged from 3 seconds to 3.8 seconds. Occasionally delays were obtained which would increase the intervals even to 10 or 15 seconds, but these were unusual. There are bound to be delays which lengthen the cycle to 80 seconds or more, but it is not safe to estimate on an average cycle of 80 seconds, as this extra time may be introduced after any one or more passes. We might take one of the shortest cycles observed in which, let us assume, a slight delay occurred during the latter part of the cycle. If, while rolling another ingot, this delay came earlier, the flywheel might not be adequate during the last passes. However, it is a simple matter to assume the minimum interval throughout and let this ideal cycle represent 25 per cent overload on the equipment. Some portion of this cycle will prevail when rolling almost every ingot, but in no case would the equipment be subject to a continuous overload. If it is desired to increase the size of the equipment over the calculated values to take care of unforeseen conditions, this can be done after the correct relation between the motor and flywheel is determined. The same factor of safety should be used on both motor and flywheel.

The curve in Fig. 4 is plotted, using intervals of three seconds between passes and six seconds between ingots. Since this cycle is to impose a load of 125 per cent on the motor, everything above 1,600 hp. should be absorbed by the flywheel during the passes, and during the intervals the difference between 1,600 hp; and 200 hp friction load, would be restored to

the flywheel. Therefore, during the three-second intervals, the motor is capable of returning 4,200 hp. seconds to the flywheel, and during the interval between ingots, 8,400 hp. seconds. The values given in the second column, representing the flywheel load during the pass, are taken from the load curve. As the flywheel is of sufficient capacity to return 4,200 hp. seconds during the intervals, it will be observed that the motor is capable of bringing the flywheel back to normal speed, after each pass, until 11 passes are reached. At the end of this interval, there is a flywheel debt of 370 hp. seconds. Therefore in starting our calculations to determine the size of flywheel, we should start with the eleventh pass and continue the cycle through the thirteenth, back to the first, and so on down to the tenth. During the interval after the first pass, the flywheel debt is wiped out and the wheel again attains normal speed. This continues until the eleventh pass is reached, at which time it again comes to the heaviest part of its cycle.

In column 3 it will be noted that the maximum energy which the flywheel must deliver is 9,100 hp. seconds, which is obtained by adding the energy required during the thirteenth pass of 7,150 hp. seconds, to that which is accumulated previous to this pass, which is 1,950 hp. seconds.

The maximum per cent speed-drop permitted is 20 per cent at 25 per cent overload. Under ordinary conditions 15 per cent will not be exceeded. In dropping down to 80 per cent speed, the flywheel has given up 36 per cent of its total energy, which, in this case, is 9,100 hp. seconds, found from our calculations. Therefore, the wheel at its normal speed would have a total of 25,300 hp. seconds.

As the speed of this mill is 70 r.p.m., a split cast-iron wheel can be used, having a diameter of 26 feet, which gives a peripheral velocity of 5,700 feet per minute. As the radius of gyration of this type of wheel is .8 of the outside radius, the velocity at this point is 4,560 feet per minute, or 76 feet per second.

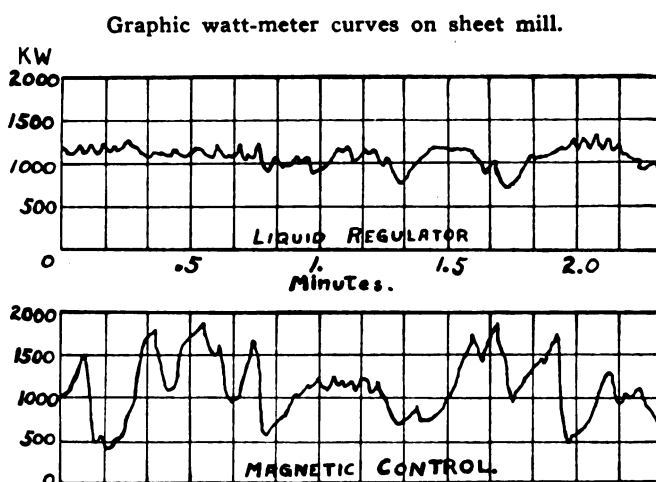


Fig. 6—Comparing liquid regulator and magnetic control on same mill—Motor secondary was switched from one control to the other to obtain test.

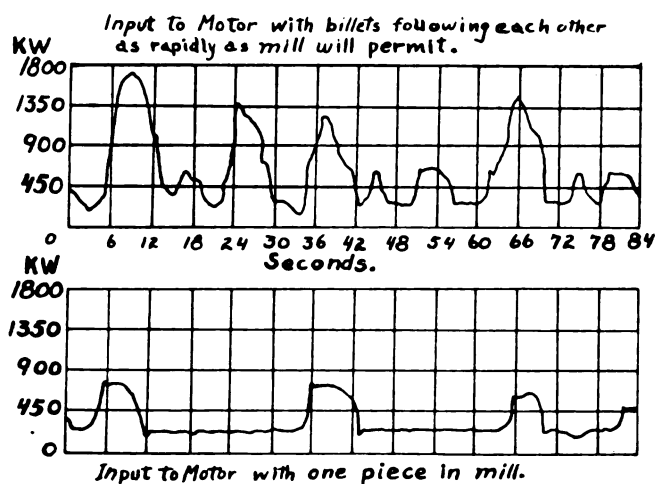


Fig. 7—Curves on cross-country mill showing feasibility of flywheel to eliminate peaks due to partial overlapping of passes.

This latter value is the one which we are to use in the formulae:

$$\text{Hp. seconds} = \frac{W.V.^2}{35,400}$$

As we are now interested in obtaining the weight of a wheel which is to have a given amount of energy, this formulae should read as follows:

$$W = \frac{\text{Hp. seconds} \times 35,400}{V^2}$$

$$W = \frac{25,300 \times 35,400}{76^2}$$

$$= 155,000 \text{ lbs.}$$

If a liquid regulator type of control is used, the input to the motor would approximate a straight line as is shown by the graphic curve in the upper half of Fig. 6. However, if fixed resistance is used in the secondary of the motor to estimate the division of the

mill-load between the flywheel and the motor, it is rather a tedious process. The motor load follows a logarithmic curve as developed by Mr. Specht in an article before the A. I. E. E. in 1909. A representative curve is shown in Fig. 5 where the motor load follows the dashed line.

It is important to take into consideration the type of control used, as some utilize the flywheel effect to a better advantage than others. On the sheet mill referred to above, we are showing in Fig. 6 the kw. input with notching in relays which regulates the amount of grid resistance of the secondary circuit of the motor, while the other curve is taken with the liquid slip regulator in the secondary circuit. The flywheel effect is the same, but the regulator does not come into action until the motor is fully loaded. With grid resistance in the secondary of the motor, the flywheel and motor slow down in direct proportion to the load, and when full load on the motor is obtained, the flywheel may be operating at 15 per cent slip and any further peak cannot be absorbed by the flywheel to the same extent as if it were at its full speed, as is borne out by the two curves. It will be noticed that the average load in each case is 1,100 kw.

Quite often motors are applied to tandem or cross-country mills on which the majority of passes are rather long and it would not be natural to expect that a flywheel would be required. The mill, however, may be so arranged that there is an overlapping of several passes which will impose short, high peaks upon the motor. Fig. 7 is a curve showing the kw. input to a motor driving a mill of this type. The lower curve was taken with but one piece in the mill and the upper curve with the mill operating at full capacity. If the necessary flywheel effect were installed, the short peaks, as shown, would not be thrown on the motor.

By-Product Coke Oven Pressure Regulation

Further Discussion of Pressure Regulation in Contention to Previous Articles on This Subject—Advantages of Simple Construction Pointed Out.

By FREDERICK W. ELLS.

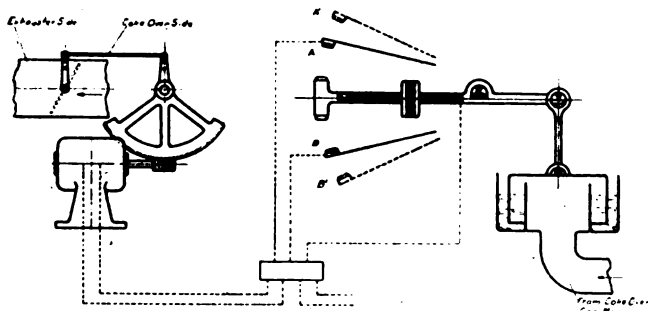
It is evident that Mr. Smoot and Prof. Trink's are not familiar with the mechanical construction of the North-western regulator described by Prof. Trink's. If they were, Mr. Smoot would not say (See THE BLAST FURNACE AND STEEL PLANT, November, 1917) as he does in describing the characteristics, under "No. 2," that the regulator has "no inherent stability." The construction of the float and contact arm are such that the arm takes a definite position for varying amounts of pressure. This is accomplished by placing the point of support above the center of gravity, as shown in Fig. 1. It is possible

to adjust the contacts A and B either close together or wide apart depending upon the closeness of regulation required. The contact will not be made on the valve moved by variations of pressure less than that for which the contact points are set.

As constructed, it requires about 1 mm. to deflect the float arm to the extreme position at which the contacts can be set. Usually they are set so that with $\frac{1}{2}$ mm. variation the valve will be operated. In the actual construction of the float it is so made that it has a dash pot effect in the oil in which it is immersed. This gives a

slight retarding effect and tends to keep the float from responding to the swirls and eddies set up in the collecting main due to the hot gases striking the cool circulating tar. These variations are violent, often amounting to several mm., but of very short duration and do not represent the real variations of pressure on the main as a whole.

The suggestion of placing a spring "D" (Fig. 3 in Mr. Smoot's article) between the float arm and the butterfly actuating arm, would not seem to be an improvement for the reason that it would change the working limits, or sensitiveness of the regulator, depending upon



the position of the butterfly valve. The position of the valve is dependent entirely upon the amount of gas coming off the ovens and the suction maintained before the cooler; either of these conditions may vary greatly, but the regulator should maintain a constant pressure and be actuated by the same $\frac{1}{2}$ mm. or less of pressure, which it could not be if a varying spring tension was interposed between the float arm and the butterfly valve in which the spring tension was greater when the valve was wide open. This would tend to raise the pressure on the collecting main when the exhauster suction was low, and lower the pressure on the main when the ex-

hauster suction was high and the valve was nearly closed.

Referring to the subject of the percentage of regulation required, Mr. Smoot says that to maintain 8 mm. vacuum with 2 mm. variation requires only 25 per cent regulation. This 8 mm. vacuum (by the way it is usually expressed as 3 mm. pressure at the ovens which might give 8 mm. suction at the valve depending upon its location) is really measured from zero pressure or it is the variation from 10,312 mm. to 10,312 + 2 mm. which is about $\frac{1}{50}$ of 1 per cent, which Prof. Trinks has pointed out—he states this is divided up between two systems, the exhauster keeping the suction constant within 10-20 mm. at the exhauster side of the valve and the coke oven regulator keeping it within + 1 mm. at the ovens. This division between the two regulators is only necessary where there are two or more batteries of ovens, due to the drop in suction in the mains leading to the different blocks. This drop varies with the amount of gas and the condition of the main. It then becomes necessary to install a regulator in the off-take main from each block of ovens. Where only one block of ovens is in use the oven regulator is often used to regulate the prime mover driving the exhauster regulator and the pressure is maintained on the ovens, within the 2 mm. limit just as satisfactorily as on the large installations where it is used directly in the ovens.

It might possibly be an advantage to operate the valve at varying speeds for other purposes, but under the conditions as applied to coke oven work it is not necessary and would add complications which are very undesirable, when it is considered that these regulators are outdoors, operating under working force of $1\frac{1}{2}$ ounces. it is seen that simplest construction should be used.

Saving Fuel in the Pittsburgh District

Attention Called to Glaring Fuel Extravagances—Installation of By-Product Coke Ovens, More Efficient Use of Blast Furnace Gas, and Utilization of Waste Heat From Open Hearths Urged. Levying Tax on Coal Used for Industrial Purposes Suggested to Improve Condition.

By W. TRINKS.

Eulogists of Pittsburgh and of the Pittsburgh district have dwelt upon the blessing which that section of the United States enjoys on account of cheapness of fuel. But in the light of recent developments this very cheapness of fuel appears more like a curse than a blessing, because it has made users of fuel wasteful to an extent which is realized by very few engineers and economists.

In placing this subject before the Bureau of Mines, before Congress and before the public, I will call attention to some of the most glaring fuel extravagances, passing by others which, although big in themselves, do

not reach the proportions of those brought out in the present paper. I will refer to the losses from beehive coke ovens, from flue gases of open hearth furnaces, and from wasteful use of blast furnace gas.

Taking them up in the order mentioned, I find that in the Pittsburgh and Connellsville districts there are (approximately) 25,000,000 net tons of coke produced annually in beehive coke ovens. From each ton of coke there are available 8,000 cubic feet of gas (62°, 30"), or more than 500 B.t.u. per cubic foot. Hence,

$$\frac{25,000,000 \times 8,000}{365} = 550,000,000 \text{ cubic feet of coke}$$

oven gas are available per day. The daily consumption of natural gas (1,000 B.t.u. per cubic foot) in the Pittsburgh district is 500,000,000 cubic feet (at maximum load). Consequently the coke oven gas which is now wasted would, if collected, supply more than half of the Pittsburgh district with gas. Coke oven gas is sufficiently high in heat value to be used in the same burners and stoves with very little, if any, change. It can be distributed through the same mains which now carry natural gas. It can be mixed with natural gas in almost any proportion with most excellent results. To make this vast quantity of gas available, a large by-product coke plant should be built sufficiently far outside of Pittsburgh to not molest that city with the smoke of the coke works, and yet sufficiently close to make a good distribution center for both gas and coke. The gas can be sold at that plant anywhere from 10 cents to 19 cents per 1,000 cubic feet at a good profit. From the above-given figures for the available quantity of gas and from the heat values of gas and coal, the daily saving of coal can easily be computed. It is very great, in addition to the value of the ammonia, the tar and the benzol, produced in the by-product plant.

With a (government or municipal) by-product coke plant in existence near Pittsburgh, another step would naturally follow, namely, the forbidding of use of soft coal for heating purposes. Ordinary coke is unsatisfactory for domestic use, because it is so hard to kindle. But, if the coke plant works with fairly low temperatures, a flaming coke well adapted for domestic use can be made, and enough gas would be produced, on account of the increased coke consumption, to supply all of Allegheny county without importing any natural gas from West Virginia. This last step would really not be a step in the direction of fuel conservation; but it would be a great boon for smoke prevention, and would give Pittsburgh an absolutely clear atmosphere.

Let us now turn to the second method by which fuel can be saved in the Pittsburgh district, namely the utilization of waste heat from open hearth furnaces. There are to-day within a radius of 30 miles of Pittsburgh more than 190 open hearth furnaces with an average capacity of 50 tons per heat. Of that number about 180 are always in operation, the rest being out for repairs. Experience with open hearth waste-heat boilers elsewhere has conclusively proven that four-boiler hp can be developed from each ton of capacity-per-heat. Hence $180 \times 50 \times 4$ or 36,000 boiler hp can be developed from the waste heat of open hearth furnaces in the immediate vicinity of Pittsburgh. Since four pounds of coal per hour are equivalent to a boiler hp, the saving per day

$$\text{is } \frac{36,000 \times 4 \times 24}{2,000} = 1,700 \text{ net tons. In large size steam}$$

turbines, one boiler hp develops from 2 to 2¼ kw, so that from 72,000 to 80,000 kw can be developed from that source. This is as much power as was developed by the Duquesne Light Company (Pittsburgh's central power generating company) up to a few months ago.

It must be admitted that some of the steel plants in and near Pittsburgh are hard pressed for floor space, so that the installation of waste heat boilers would require careful study; nevertheless, the boilers can be installed without any doubt.

The third method by which great quantities of fuel can be saved in and around Pittsburgh consists in the better utilization of blast furnace gases. It is well known that from each 100 tons of blast furnace capacity-per-24-hours from 1,600 to 2,000 hp can be generated for use outside of the blast furnace plant, if the blowing engines are driven by gas engines and if electrical energy is likewise produced by gas engines from the surplus gas.

At the present time this economical method is followed only in two blast furnace plants in Pittsburgh, and there only for a few furnaces, so that surely not more than 10 per cent of the blast furnaces in the Pittsburgh district are thus equipped. The blast furnace capacity of that district is about 2,400 tons per day. Let 2,400 tons be served by gas engines at the present time, then 21,600 tons per day are not so equipped. Hence from

$$1,600 \text{ to } 2,000 \times \frac{21,600}{100} \text{ or from } 340,000 \text{ to } 430,000 \text{ hp}$$

can be generated by gas engines. With the present steam equipment for both blowing and power generation, not more than 300 hp are generated for each 100 tons of

$$\text{furnace capacity, which means that } 300 \times \frac{21,600}{100} \text{ or}$$

65,000 hp are now generated from surplus gas. The difference is somewhere between 270,000 and 370,000 hp. Let us roughly take it to be 320,000 hp, or 240,000 kw.

The circumstance that with the highest possible type of steam equipment, up to 800 hp can be generated from surplus gas for each 100 tons-per-24-hours capacity does not alter the argument, because, with the present equipment, it is not done. In some of the furnaces there is not only no surplus gas, but coal must be burned under the boilers to keep the wasteful blowing engines in operation.

On the basis of 1½ pounds of coal per kw hour, the saving of coal per day, due to better utilization of the blast furnace gas in the Pittsburgh district, would amount

$$\text{to } \frac{240,000 \times 1.5 \times 24}{2,000} = 4,300 \text{ net tons per day.}$$

These figures are stupendous. They immediately raise the question: why were not these improvements made long ago? The answer is, that the installation of fuel saving equipment requires a great deal of money. If interest, depreciation, maintenance and repair, and cost of operation are included, the gain, while unquestion-

able, is not sufficient in the Pittsburgh district to attract investment, compared to the financial gain due to increased output, which can be had by installing more low-first-cost equipment which wastes fuel. For instance, if we have the choice between installing waste-heat boilers on our present open hearth furnaces on one side, and installing additional open hearth furnaces, we do the latter. We may consider the installation of boilers in conjunction with the new equipment, but we soon drop the thought, because it requires more money than we wish to spend. Thus the tremendous waste of fuel goes on, at an ever-increasing rate.

What can be done to stop it? As long as fuel is as cheap as dirt, nothing can be done, because the standard commercial formula to make the total cost of interest, depreciation, labor, maintenance and repair, and of fuel a minimum always leads to low-first-cost and wasteful equipment in and near Pittsburgh. To stop the waste, fuel must be made dear. Nobody can make fuel dear in Pittsburgh but the government, and the latter can increase the price by putting a tax on it. To put a tax on fuel looks like hindering free commercial development. It looks Prussianism in its worst form. Yet, many government actions which were thought impossible before the great war, are now carried out without serious objection.

The author recommends that the government levy a tax of at least \$1.50 per ton on all coal used for industrial purposes in the Pittsburgh district, but that it heavily contribute from the income thus derived toward the introduction of fuel-saving equipment. Other districts should be treated in a similar way, and the tax should be graded in such a manner that the price of coal will nowhere in the United States drop below a certain minimum value which is to be sufficiently high to encourage the installation of fuel-saving equipment.

As an example, there exists now in the Pittsburgh district a great deal of antiquated steam blowing equipment which is in bad repair, and will soon have to be replaced. Under the present conditions the old engines are patched and re-patched, but as soon as the tax on fuel is applied, this equipment becomes impossible, because its operation is too expensive. In replacing it, the owner will hardly install new cheap, wasteful equipment and continue to pay large sums for fuel, but he will replace it by more expensive, but fuel-saving equipment. In the latter case, the government pays say three-quarters of the difference between the costs of the cheap and of the economical equipment. The cost of the fuel plus tax will be no more than it was under the old arrangement for fuel alone, on account of the smaller consumption of the latter, and the government has gained its object to conserve fuel resources. It is not desirable to have the government pay the whole difference between the costs of

the wasteful and the economical equipment, because doing so would probably lead to foolish refinements.

Objections will probably be raised to a tax on fuel. Let us consider some of them. It may be argued that the money gathered from low-fuel-cost districts, such as Pittsburgh, Johnstown, Birmingham, will go into the "pork barrel" and will be used for building monumental postoffices in small towns in the West. This objection can easily be taken care of by framing the law in such a manner that a fund must be collected of sufficient size to take care of all installation of fuel-saving equipment, and that only a surplus in excess of that fund can be used for other purposes.

A second objection will probably be this: The examples of wastefulness cited in this paper refer to coke oven, blast furnace and steel works practice only. It would not be equitable to penalize other industries for the wastefulness of the iron and steel industry. This objection, too, is void. In practically all of the leading power plants of the Pittsburgh district, the stack gases have a temperature of 650 to 700 deg. F., which means that huge quantities of heat are wasted by passing up the smokestack. Economizers are unknown (with one single exception). The majority of power plants have wasteful engines, and so forth. The fuel tax would change all that, in addition to revolutionizing the fuel methods of the steel plants.

The fuel tax would have several additional advantages:

Everybody expects a slump in the steel and in the machinery business after the war has ended. The fuel tax will prevent the slump by compelling the coke ovens, blast furnaces and steel works to install more economical equipment, thus keeping the machinery business, and all the industries dependent upon it, going.

The second advantage would be the attitude of the fuel consumer toward the bureau of smoke regulation. Pleas of the smoke inspector for better combustion of fuel on the ground of better utilization of the fuel are now met by a broad grin reaching from one ear to the other and meaning: "What do we care for fuel economy? The stuff is so cheap that it does not pay to practice economy."

Of course, the suggestion comes too late to save any fuel in the present period of great demand and insufficient supply. Waste heat boilers, gas engines and by-product coke ovens cannot be purchased and installed in a hurry. But it takes an emergency like the present one to impress upon us the terrible waste of fuel going on around us, and it takes an emergency like the present one to put enough steel into the backbone of the government to reach out and restrict the unbridled liberty of the individual or the corporation for the common good of the whole nation. Putting a tax on fuel is a truly patriotic move.

Errata - In December issue, pp. 556-7, figures 3 and 4 should have been transposed.

Steel Production by the Duplex Process

Handling of Materials Between Units by Overhead Traveling Cranes in Combination With Cars and Haulage System or Electric Locomotive.

By J. K. FURST,

Vice President and Engineer Pennsylvania Engineering Works.

Part 3.

In the previous installment of our article we described the method of handling the materials between the different duplex units exclusively by overhead traveling cranes. In the present installment we will describe in a brief way the handling of the materials be-

when the latter are tilted over into a horizontal, or receiving, position. It will further be noted that the mixers have been placed at a higher elevation, so that they can pour into a ladle mounted on a car operating on a common platform track between the mixers and con-

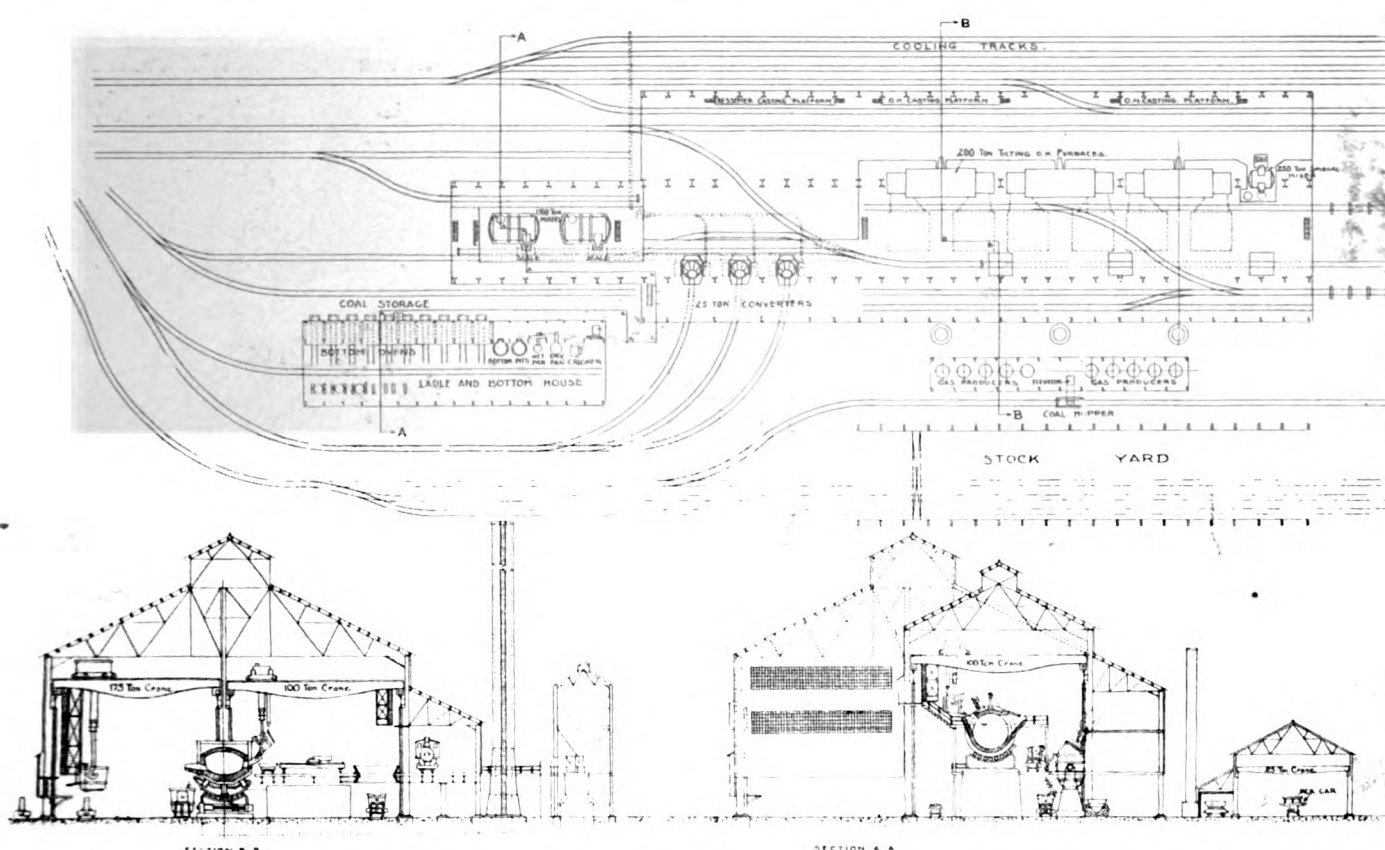


Fig. 1—Handling of material between different units of a duplexing plant by means of overhead traveling cranes in combination with cars and haulage system or electric locomotive.

tween the different units by the overhead traveling cranes in combination with cars and haulage system or electric locomotive.

In the employment of this latter method, the arrangement will be about as shown in Fig. 1. By making a comparison between Fig. 1 of this installment and Fig. 1 in the installment of the September issue, the reader will note that the arrangements are practically the same, with the exception of the relation of the hot metal mixers to the converters. It will be noted that the mixers have been advanced until their pouring spouts come in line with the noses of the converters

verters at an elevation slightly lower than the converter trunions.

The mixer is charged and discharged in the manner previously described. After the metal has been poured and weighed on the platform scales, the car is advanced either by an electric haulage system or by an electric locomotive, until it comes within range of the converter to be charged, when the contents of the ladle is poured into the converter without removing the ladle from the car. The ladle is usually overturned by either an electric or hydraulic jib crane, as shown in Fig. 2. The metal is blown and poured from the converter in the

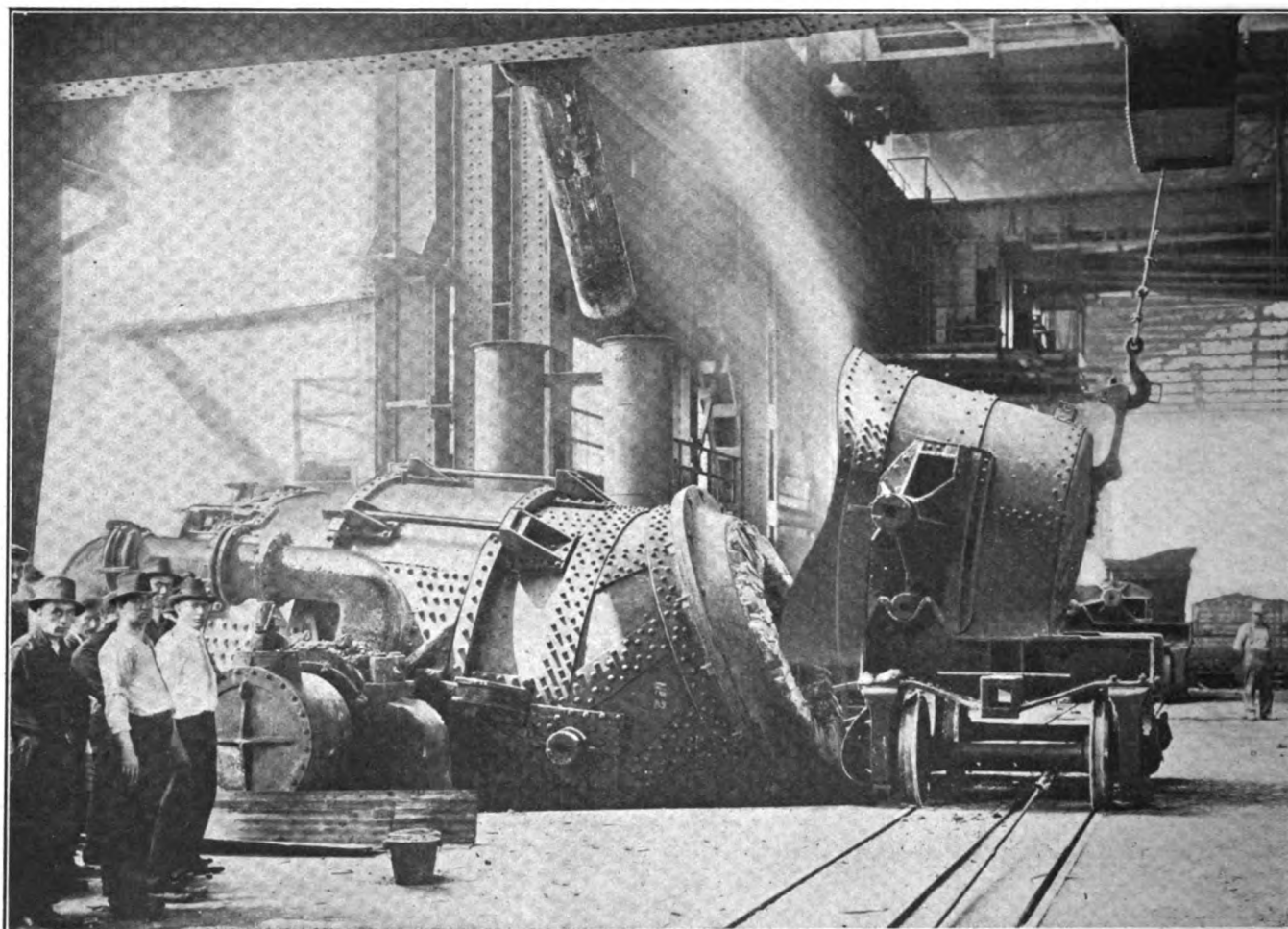
same manner as previously described; but, instead of pouring into a ladle resting on the ground, it pours into a ladle mounted on a car operating on a track system between the converters and the open hearth furnace, the track in the open hearth building being located on the ground floor and just to the rear of the regenerators.

The ladle in this case can be either of 30 or 65 tons' capacity, dependent upon the method of operation as to whether it is intended to hold either one or two heats of the converter, preferably the latter, on account of the economies gained thereby, due to conservation of heat,

spout with narrow and deep pouring vent so that the slag would be retained in the ladle.

The ladle is then returned to the hatch, where the slag is dumped into a slag car which has been carried along as a trailer to the hot metal car, and which has been shifted into position beneath the hatch for this purpose while the ladle contents were being charged into the furnace.

After the slag has been dumped, the ladle car is again shifted into position beneath the hatch, where it receives the ladle to be returned to the converter.



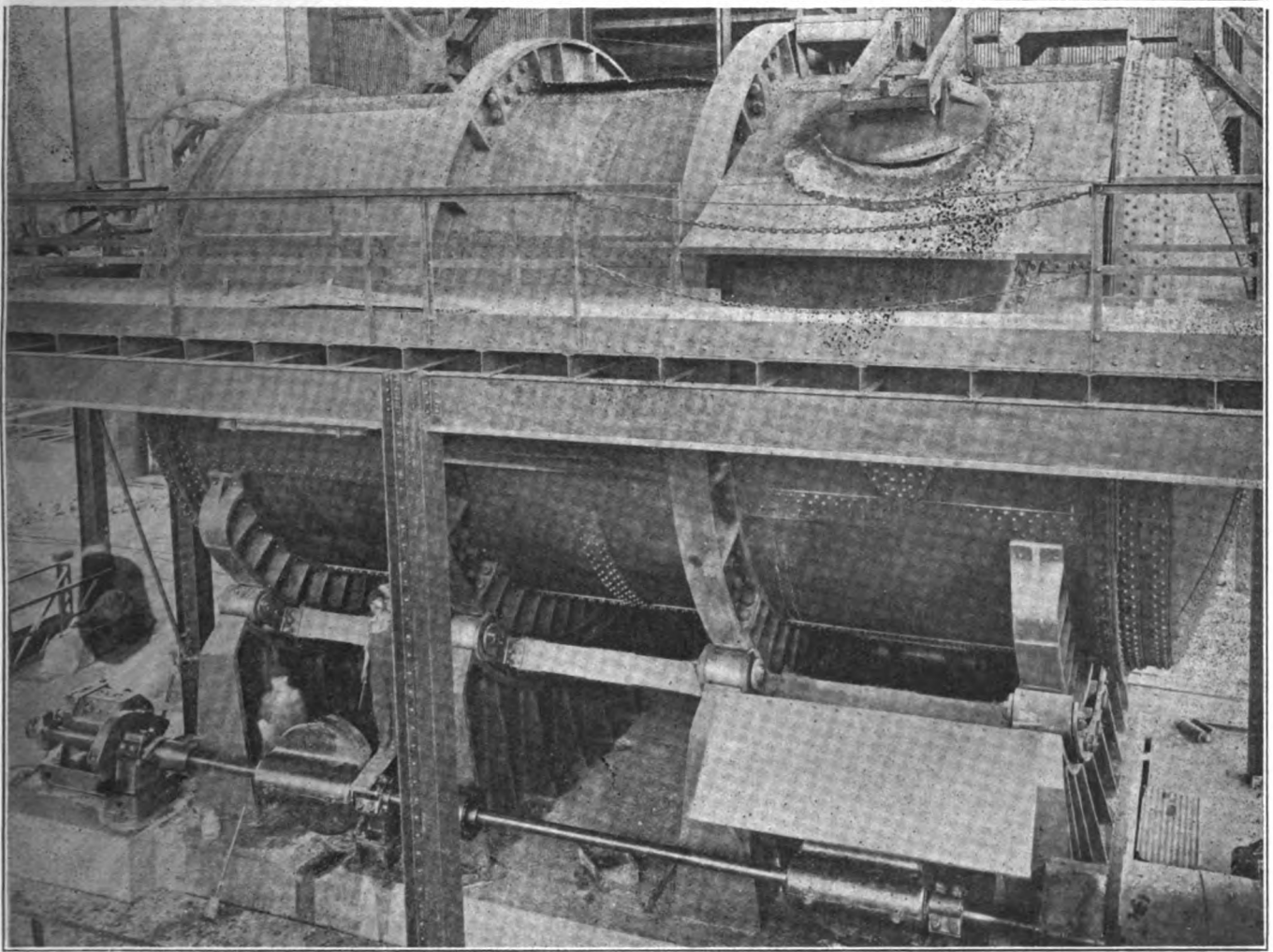
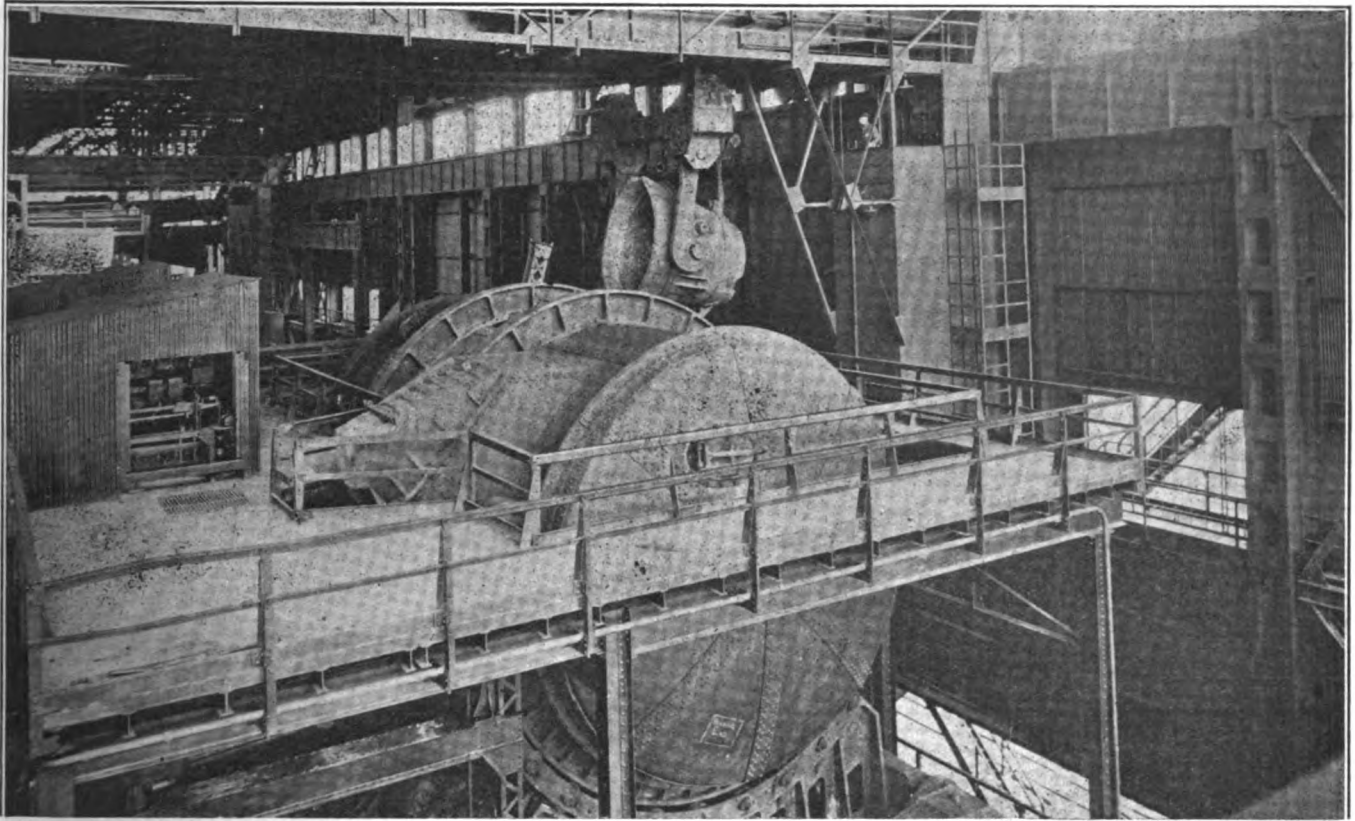
Converter in position to be charged.

less sculling, and only 50 per cent of handling.

Directly over this hot metal track on the open hearth charging floor, and midway between the furnaces, are located hatches whose sides are protected by heavy castings. After the heat has been poured from the converter, the car is advanced, either by haulage or electric locomotive, to position beneath the hatch of the furnace to be charged, after which the ladle is lifted from the car, by the hooks of the overhead traveling crane descending through the hatch for the purpose, and thereby charged into the furnace, either by the side pour or lip pour method. If the latter method is employed, it is necessary to have an especially constructed

It will be noted by an inspection of Fig. 1 that there has been provided a branch between the hot metal track adjacent to the converter and the track on the pouring side of the open hearth building. This is for the purpose of transporting the blown metal to the casting platform on such occasions as it is found desirable to operate the converter on straight Bessemer practice.

By a further inspection of Fig. 1 it will be noted that there has been provided a small hot metal mixer located in line with, and at the extreme end of, the battery of open hearth furnaces, also that the mixer has been provided with two delivery spouts, one delivering to the charging side, and the other to the pouring side, of the



1,300-Ton hot metal mixer—The upper illustration shows ladle in charging position and location of control—The lower illustration shows opening for charging and method of rotation,

open hearth furnaces. This mixer is for the purpose of carrying special iron for recarburizing in the ladle, and for the additional purpose of using iron instead of high carbon steel to obtain the violent reaction in the open

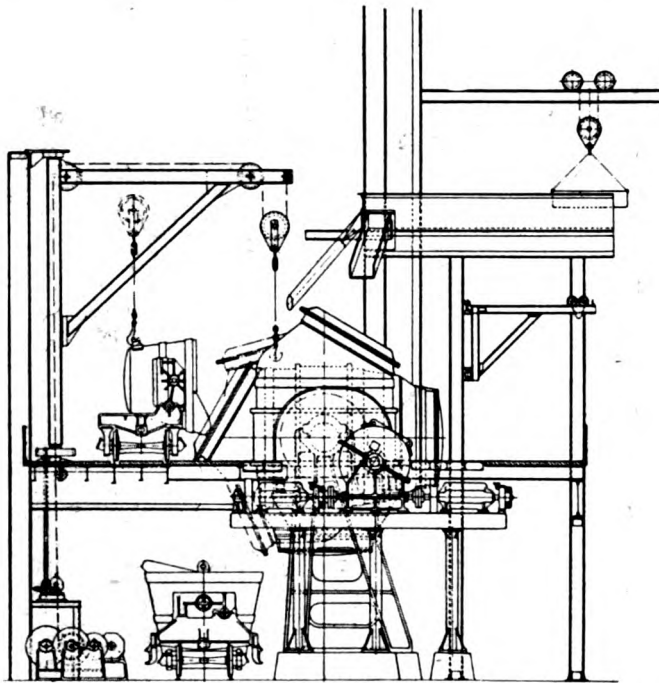


Fig. 2—Showing method of pouring charge and pouring converter.

hearth furnace so necessary at the critical stage of steel making by this process; thereby effecting a saving due to the gaining of a certain tonnage of steel without passing through the converter, and by permitting the converter to operate more uniformly, having the converter blow all heats alike.

It is our judgment in the matter that the methods employed as described in the foregoing are superior to those previously described, where everything was handled by overhead traveling cranes, as this method has the triple advantage of being more economical, more expeditious and safer.

From time to time we have been asked what difference there is between converters for duplexing and those for straight Bessemer practice. In this connection we can advise that there is no particular difference between the converter units, but the chief difference lies in their arrangement. Due to the rapidity of operation in the straight Bessemer practice, it is preferable to handle blown metal by hydraulic post pouring crane, rather than by overhead traveling crane or other means.

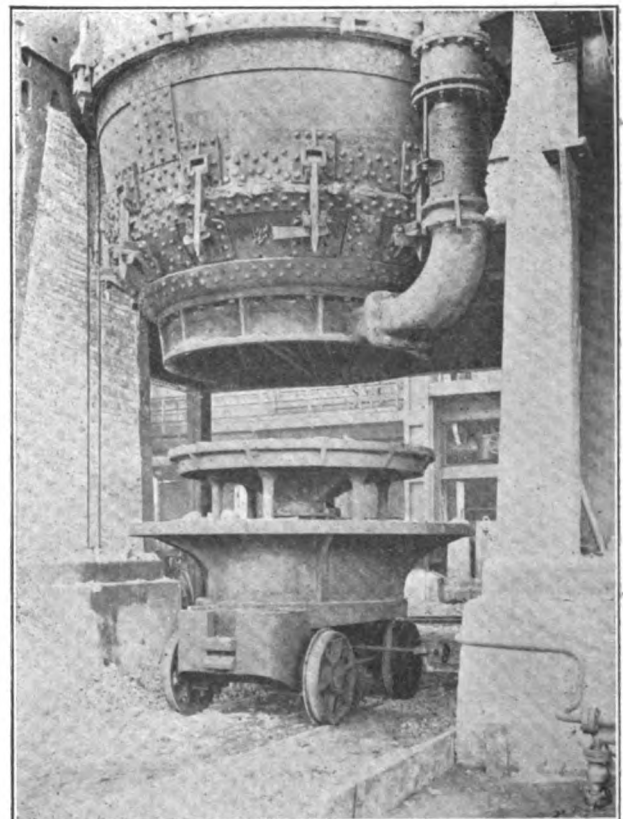
We also desire to correct here an error in the October issue—"the blast is supplied at a maximum pressure of 30 pounds and at the rate of 1,500 pounds per ton of metal blown," which should have read, "at the rate of 1,500 cubic feet per ton of metal blown."

While steel production by the duplex process will have become firmly established by the time of the

termination of the present world wide conflict, we do not believe it will have then reached in any degree its maximum stage of development; but that it will continue to be employed by an ever widening circle of manufacturers, and that it will improve in both method and design so that the world will come to recognize that the despised tool laid down as useless in another continent has been taken up and perfected by the hasty American, who is so frequently charged with undue impatience.

In the first installment of this series the author classified the two methods of plant arrangement, saying: "The arrangement of the plant is dependent upon local conditions and the selected method of operation; that is whether the plant is entirely new, which is seldom the case, where the arrangement and method may be selected; or whether it is partly new and partly old, such as new converters and mixers but old open hearth furnaces; or a new plant throughout located in an existing steel making department, all of which has its bearing on the arrangement of the plant. But, roughly speaking, there are two distinct methods of operation employed, as best adapted to existing conditions.

"First—Handling the materials between the different



Showing converter bottom.

units exclusively by the overhead traveling cranes.

"Second—Handling the materials between the different units by the overhead traveling cranes in combination with cars and haulage system or electric locomotive."

Gas Circulation in Regenerator Checkers

General Laws Based in Part Upon the Research Work of
Professor Groume-Grjmailo of Petrograd Applied to Blast
Furnace Stoves.

By A. D. WILLIAMS.

PART 1.

Many variations have been made in the designs for the checkers of hot blast stoves and furnaces in the endeavor to utilize the heating surface to the best advantage. Some of these designs neglect the elementary principle that a cold gas, being heavier than a hot gas tends to sink to a lower level, while a hot gas has a tendency to rise, although this principle has been utilized for many years in the design of hot air heating systems in buildings. The consideration of

goes on gas. This difference will nearly triple the volume or reduce the specific weight of a gas by two-thirds.

During its passage through a checker work the gas or air is either giving up heat to the checker and, thereby, cooling itself; or it is receiving heat from the checker and cooling the brickwork. The pressure is practically constant with either the gas or the air. Under these conditions the problem is to so subdivide

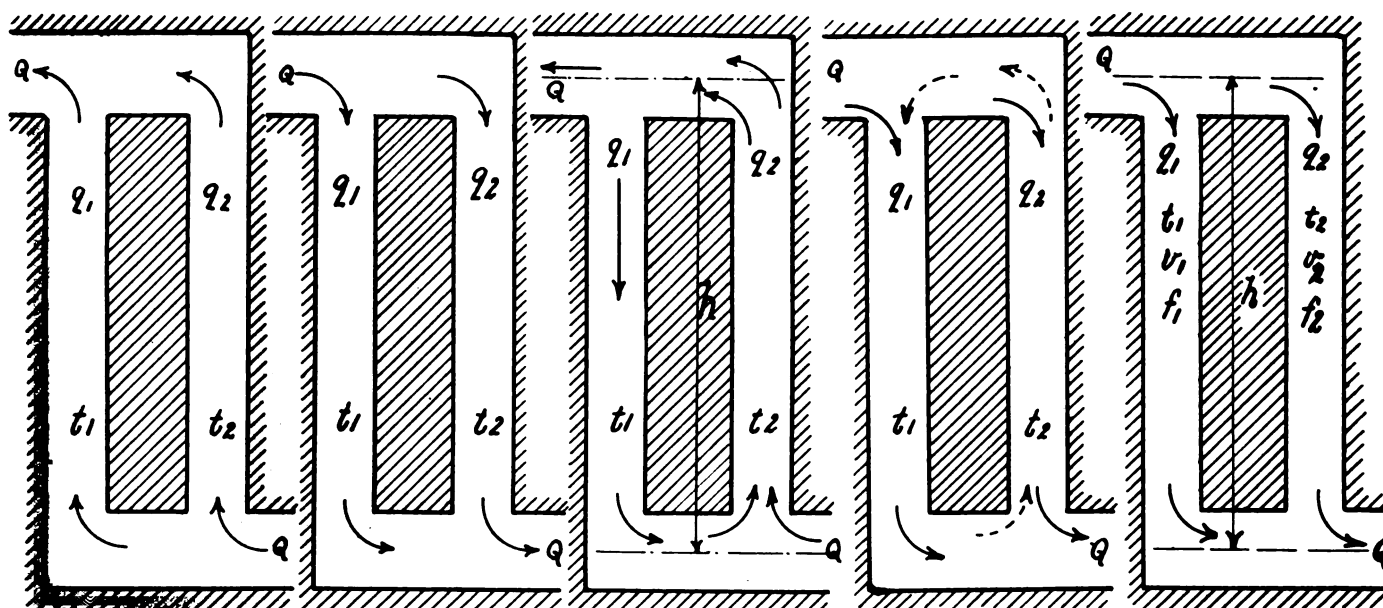


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Circulation of gas through regenerator checker work.

this difference between the specific weights of gases due to their temperature explains why certain portions of the checker work heat and cool more rapidly than other portions and why certain passes have a better efficiency than those next to them.

It is well known that both temperature and pressure affect the volume of a gas and therefore its specific weight. In furnace work the pressure differences are comparatively slight, at the most a few millimeters of water, and while even the slightest difference in pressure affects the volume, the coefficient of correction is so small that it may be neglected in most cases. The coefficient for temperature, however, is considerably higher, because furnace work deals with large temperature differences. For instance, in a hot blast stove the temperature difference between the top and bottom of the checker work may be over 500 deg. C. when the stove comes off gas and 600 deg. when it

the gas or the air into a number of parallel currents that the temperature drop or gain of every current or vein will be as nearly equal as possible.

Assuming that a current of hot gas Q , Fig. 1, is to be subdivided into two equal ascending veins, q_1 and q_2 , which are giving up heat to the walls that surround them, suppose we have effected this subdivision and that the temperatures of the streams, t_1 and t_2 , are equal. Now if for any reason there should be more radiation or heat absorption from the current q_1 , its temperature will drop below that of the other stream and the weight of this column of gas will increase. This will reduce the velocity of the gas in that passage. The reduction in velocity will cause a still further lowering of the temperature. At the same time the column q_2 will increase in temperature. The cumulative effect will be such that finally the current q_1 will be completely stopped and all of the gas will pass in

the current q_2 . It may even happen that a current may be set up in a downward direction in q_1 , as shown by the arrow in Fig. 3.

If on the contrary we endeavor to subdivide the current of hot gas Q into two equal descending veins, as in Fig. 2, should one of these veins lose its heat faster than the other, it will increase in density. This increase of density will then tend to increase the velocity of that vein, increasing the quantity of gas passing until the temperature loss in both veins will be the same and the temperatures of the two veins will be equal. So that should the friction loss and temperature loss in the two be equal, the quantity of gas flowing will be equal.

Let us assume that we have subdivided the current into two equal descending veins having equal temperatures, when cold air or gas is being heated in a checker, Fig. 4. If one of these branches should heat less rapidly than the other then its temperature t_1 becomes less than t_2 and this increases the density of q_1 resulting in increased velocity which decreases the temperature still more. In the meantime q_2 has lost velocity and its temperature tends to increase further, until the entire current is passing through q_1 , while the vein q_2 will have established a reverse current as indicated by the dotted arrows in Fig. 4.

The assumption is now made that the cold current to be heated is subdivided into two ascending veins. If one of these veins is larger than the other its temperature will be less which will tend to decrease its flow, while the lesser vein will tend to increase in temperature which will tend to increase its rate of flow until the temperature increase of both veins is equal. Therefore, when the friction losses and temperature gains of the two veins are equal, their flow will be equal. This condition is shown in Fig. 1.

It is possible to derive an expression that will enable the frictional resistance of the two passages to be approximated where one of the passages loses or radiates more heat than the other as the gaseous current subdivides itself accordingly. In Fig. 5 such a case is represented, the current being subdivided in two branches, q_1 and q_2 , the average temperatures of which t_1 and t_2 are different, the average velocities v_1 and v_2 are also different and the friction losses of which f_1 and f_2 are expressed in millimeters of water. In order to maintain the conditions of equilibrium between the two it is necessary that the increase in hydrostatic pressure in the two branches shall be equal.

If there were no loss in hydrostatic pressure for impressing the velocity of the current in the two branches and for overcoming the friction, the hydrostatic pressure for the branch q_1 in millimeters of water would be:

$$1.29 h \left(1 - \frac{1}{1 + a t_1}\right) = 1.29 h \frac{a t_1}{1 + a t_1}$$

And for q_2 :

$$1.29 h \frac{a t_2}{1 + a t_2}$$

The weight of the off gases being assumed as 1.29 kg. per cubic meter.

A portion of this increase in hydrostatic pressure is expended in overcoming friction and impressing the velocities v_1 and v_2 upon the flowing gas. These losses may be expressed in millimeters of water as follows:

$$\frac{v_1^2}{2g} \times \frac{1.29}{1 + a t_1} \text{ and } \frac{v_2^2}{2g} \times \frac{1.29}{1 + a t_2}$$

Then owing to the equality of the hydrostatic pressures in the two branches, the following equation is obtained:

$$1.29 h \frac{a t_1}{1 + a t_1} - f_1 - \frac{v_1^2}{2g} \times \frac{1.29}{1 + a t_1} = 1.29 h \frac{a t_2}{1 + a t_2} - f_2 - \frac{v_2^2}{2g} \times \frac{1.29}{1 + a t_2}$$

This expression has six variables of which five must be known in order to determine the sixth. The temperature losses or difference between the top and bottom of the checker may be readily measured. The velocities may be measured.

W. A. Mojarow, *Revue de la Societe russe de Metallurgie*, 1, 1913, has derived an expression for the coefficient of friction in Cowper stoves and verified the same in applying it to computations for such apparatus. According to this experience, the coefficient of friction of gases against brickwork can be taken as 0.016, with sufficient precision for the purposes of metallurgy. The friction may be determined by the following formulas:

$$f = k \frac{SL}{w} v_t p_t = k \frac{SL}{w^2} q_n p_n = \frac{B}{w^2} q_n p_n$$

In which:

- f = the friction in millimeters of water;
- k = the coefficient of friction = 0.016;
- S = the perimeter of the passage in meters;
- L = the length of the passage in meters;
- v_t = the velocity in meters per second of the gas at t° ;
- p_t = the weight of the gas in kilogrammes per cubic meter at t° ;
- t = the average temperature of the gas centigrade;
- q_n = quantity of gas flowing in cubic meters at 0° —760 m/m;
- p_n = specific weight of gas, kilogrammes at 0° and 760 m/m;
- B = the surface area of the passage in square meters;
- w = cross-sectional area of passage in square meters.

A few years ago A. E. Maccoun made some experimental observations of temperatures on Cowper stoves at the Edgar Thomson Works. (American Iron & Steel Institute meeting, May 28, 1915). His observations showed that the outer checker openings close to the shell took more gas when heating and less air when on blast, the air seeking the central section of

the checker close to the combustion chamber wall. This is exactly the distribution that must occur in a stove of this design (two-pass, side combustion). The only way in which the distribution of both gas and air may be improved is by cutting down the radiation losses through the shell. The checker work in this stove is arranged for the rational circulation of the air and the hot gases. The main defect in the Cowper stove is the vertical combustion chamber which has a tendency to pull the flame from the burner into the stove and to cause explosive burning of the gas. With slight changes the efficiency of this combustion chamber may be improved to permit cutting the air supply closer to that theoretically required and eliminating the explosive burning.

The fact that the stove gave slightly better results when operated with three chimney valves than with two shows that the two chimney valves were too small and strangled the flow. Otherwise there is no reason for more than one valve unless the space below the checkers is too small in height and volume.

Multiple-pass stoves have the disadvantage that the circulation of the gas and air in some of the passes is, of necessity, in an irrational direction and for that reason such passes have a very small heat value as compared with their possible value with correct circulation.

Convection currents in gases and air, due to slight temperature differences, are by no means inconsiderable as a difference in temperature of 1 deg. C. is sufficient to impress a velocity of 0.268 meters (0.88 ft.) per second. This velocity increases directly as the square root of the difference in temperature. This velocity would act to carry away the heated air or the cooled gas from the checker surface even if there was no current, so that the heat transfer cannot be greatly reduced by reduced velocity of the air or gas stream. These convection currents tend to rise when heat is being given out by the brickwork and to sink when heat is being absorbed, and it is advantageous that the working current or circulation of the air and gas should be in the same direction, for in this case, they tend to reduce the friction loss.

The prevailing practice of operating stoves is a definite time on gas and a definite time on air, often three times as long on gas as on air, with four stoves. The hot blast temperature is watched, but the temperature of the off-gases of combustion is rarely watched except when a test is being run. There is a limit to the amount of heat that may be stored up in the brickwork, an economical limit and a practical limit. The practical limit is reached when the temperature of the checker brick approaches the flame temperature. The economical limit is reached when the off-gases commence to increase in temperature at an increasing rate, which occurs when the brickwork is approaching the heat saturation point, as it may be termed. That is when the upper portion of the checker has reached a

point where the curve of its heat-absorbing capacity commences to flatten out, and the temperature gradient from the top to the bottom of the checkers commences to depart from the straight line, or when the distance between isothermal lines becomes greater at the top of the checker than it is at the bottom. The cooling off of the checker follows a similar law. However, the gas temperatures in the checker flues tend to follow a curve in which the isothermals will be closer together at the top and then increasing until they come very close to a straight line location. With a dirty checker work or one imperfectly insulated, the temperature gradient will depart from the straight line. The radiation loss will be greater at the top and this will tend to reduce the vertical distance between the isothermals. A dirty checker will not absorb or give out heat as fast as a clean one. It is impossible to eliminate all of the flue dust and cinder and in order to compensate for this the height and the heating surface must be increased.

There is a definite relationship between the amount of heating surface, the thickness of checker wall, the heating and cooling time, the velocity of the gas, cost of checker and cost of fuel. The larger the heating surface, the faster it is able to absorb or give out a given amount of heat, the smaller the temperature differential required between the surface and the passing gas and the lower the rate of heat interchange per unit area. The thinner the checker wall, the faster it will heat or give off heat, and the smaller the temperature differential between the surface of the wall and the center or the greater the volumetric efficiency of the brickwork and the shorter the time of heating or cooling. In a 2-inch (50 m/m) wall, the center will heat to a temperature 99 per cent of the surface temperature in 30 minutes, while two hours will be required to bring a 4-inch (100 m/m) wall to this temperature condition. The cooling time will be the same if the heat capacities of the passing gases and their temperature differentials are equal. The velocity of the passing gases must be sufficiently slow to permit the heat interchange to be affected within the length of the checker. At high velocities the hot gasses will not have time to lose their heat and the air will be unable to absorb the heat. The circulation velocity should be such that the passage through the regenerator occupies several seconds, giving a temperature gain or loss of from 100 to 200 deg. per second. The cost of fuel and the cost of checker work must be considered, a balance being struck. Where the cost of fuel is low the amount of checker work may be cut down somewhat, while the higher the cost of the fuel the more checkerwork it will pay to install, within limits.

The curves in Fig. 6 show the time required for the central plane of walls of different thicknesses to reach any given percentage of their surface temperature. These curves are computed by a formula developed from Fourier's series. The rate of heating

may be slower than that indicated by the curve, but cannot be faster, as the rate at which the heat is conducted away from the surface limits the speed of heating. These curves reveal the fact that a checker wall may be too thin for economical work and that

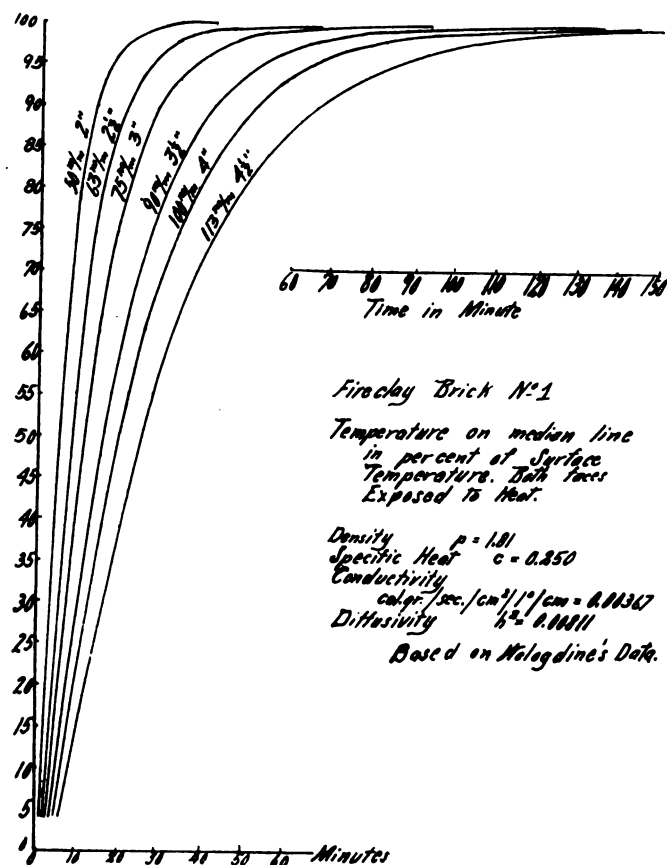


Fig. 6.

the rate of heating varies as the square of the thickness. The curves are not absolutely exact for checker construction, which consists of a number of square cells, as it does not take account of the corner effect which acts to slow down the rate at which the checker structure comes up to heat. A formula covering the corner effect could be developed, but it would be rather complicated in use.

The thickness of the checker wall should be proportioned to suit the heating or cooling time; that is, it is necessary to provide a certain amount of heat storage capacity in connection with each unit of heating surface in order to secure economical working. If the wall is too thin the heat gradient from the hot to the cold end of the checker becomes a curve and the distance between the isothermal lines at the hot end increases and the heat of the off-gases increases, resulting in the waste of fuel when heating. In cooling or when heating the air will be an excessive heat differential at the cold end at the start. If the walls are too thick the heat gradient may be curved, due to an increased distance between the isothermals at the cold end of the checker. There will be too much re-

serve heat storage capacity or the heat interchange will be inefficient. In connection with the wall thickness it is necessary to consider the size of the checker opening. This also hinges on the cleanliness of the gas. The heat conductivity of the dust and cinder deposit is only about one-tenth that of the brick. This deposit is cumulative and tends to stop up those openings through which the greatest quantity of the heating gases pass. It is, however, possible to remove the largest portion of the dust, and the cleaner the gas the better. Another point to be considered in connection with the size of the checker opening is: it should be large enough to permit it to be brushed out. This limits the minimum size of the checker opening to about 3 inches square or larger. Too large a checker opening is a disadvantage as it reduces the weight of the brickwork and is not efficient in transferring the heat to the air, 6 inches is about the maximum limit and smaller openings are desirable except with dirty gas. With clean gas, $3\frac{3}{4}$ to $4\frac{1}{2}$ -inch openings are to be preferred. If convection currents could be prevented it would take about 60 sec-

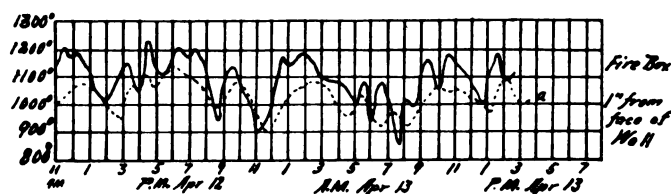


Fig. 7.

conds to heat a 3-inch square column of air to 80 per cent of the checker temperature; however, the convection currents greatly reduce this time. These currents may have a velocity of from 1 to 3 meters per second in addition to the average velocity of the air corrected for temperature in the upper portions of the checker work.

Convection currents likewise facilitate the heating of the brickwork as they give an additional downward velocity, carrying off the cooled gases.

One of the interesting points of checker design is the heat differential which is necessary between the hot gases and the brickwork and between the brickwork and the air. Some data upon this subject was obtained as a by-product in Ray and Kreislinger's investigation of "The Flow of Heat Through Furnace Walls." (Bureau of Mines bulletin No. 8.) The curves in Fig. 7 are reproduced from this publication, the dotted line showing the record from a thermo couple 1 inch back from the face of the brick exposed to the heat, the full line gives the firebox temperature. It will be noticed that the brick temperature lags behind the furnace temperature somewhat. The interesting feature of these curves is that the temperature gradient between them is rarely greater than 150 deg., which includes 1 inch of brick as well

as the surface resistance between the hot gas and the brick.

Radiation losses are frequently estimated as from 10 to 12 per cent of the total heat. Stoves are generally built with a 2-inch air space inside the shell, then an 18-inch brick wall. Latterly, there has been a tendency to fill this air space with infusorial earth or similar insulator. This addition of infusorial earth is equivalent to increasing the outer wall to about 31.5 inches of brick. A fear has been expressed in some quarters that increasing the insulation would result in more rapid deterioration of the checkers and other brickwork, possibly in fusion. Without the use of preheated air, the theoretical flame temperature of blast furnace gas will not exceed 1,400 deg., except

in rare instances and will generally be 200 deg. less. There are refractories which will stand such temperatures. Any increase in the heat insulation, by cutting down the radiation losses, adds to the capacity of the checker work by equalizing the flow of the heating gases and of the air being heated through the entire checker area, an equalization which is impossible of accomplishment by baffle walls or domes. In fact, it makes very little difference whether the stove is doomed or not, provided there is a chamber above the checker. The amount of heat insulation to be added to the usual firebrick wall must be settled on the basis of "will it pay." But it is necessary to eliminate the air space as far as possible.

Review of Iron and Steel Literature for 1917

Important Technical Literature Published During 1917 Concerning the Iron and Steel Industry Classified—War Influence Reduces Amount of Foreign Publications.

By E. H. McCLELLAND,
Technology Librarian, Carnegie Library of Pittsburgh.

In literature relating to the ferrous metals 1917 was less prolific than certain previous years. The foreign literature, usually of considerable extent and value, was of course, less in evidence.

The brief list of books and serials given below includes only the more important ones published in English during 1917, with a few which appeared in 1916, but which were reviewed mainly in the technical press of 1917. Only a rough classification has been attempted.

Iron Ores, Ore Handling, Etc.

United States Geological Survey, Bulletin 645, 1916, is a "Bibliography of North American Geology," etc., for 1915. It indexes books, magazine articles and official State and Federal publications both by regions and by economic products. A similar bulletin covering the year 1916 should soon be available.

The best general index to mining and metallurgy, the "Mining World Index," formerly published semi-annually, was discontinued at the end of 1916 when the "Mining World" was absorbed by the "Engineering and Mining Journal."

Crowell and Murray—Iron Ores of Lake Superior; containing some facts of interest relating to mining and shipping of the ore, and location of principal mines; with original maps of the ranges. Ed. 3, 1917. 316 pp. Penton Pub. Co., Cleveland, O. \$3.50.

Franke, Georg.—Handbook of briquetting; tr. by F. C. A. H. Lantsberry. V. I., 631 pp., 1917. J. B. Lippincott Company, Philadelphia. \$9.

V. I.—The briquetting of coals, brown coals and other fuels.

Comprehensive work, covering technology fully, and including data and statistics based mainly on the industry in

Germany. The second volume will be devoted to briquetting of ores.

Miller, Ernest W.—Condensed information about the locating of metalliferous ores, petroleum, natural gas, subsoil water, etc., by electric prospecting with scientific instruments. 28 pp. 1917. Privately printed; St. Louis, Mo.

Zimmer, George Frederick—Mechanical handling and storing of material such as grain, coal, ore, timber, etc., by automatic or semi-automatic machinery, together with the various accessories used in the manipulation of such plant. 752 pp. D. Van Nostrand Co., New York; 1916. \$12.50.

Contents—Continuous handling of material. Continuous handling of material by pneumatic and hydraulic means. Intermittent handling of material. Unloading and loading appliances. Miscellaneous installations. The automatic weighing of material.

Includes handling of coke and charging of blast furnaces.

Blast Furnaces.

Very few important books have ever been published on the blast furnace and the few contributions to the literature of the subject during 1917 compare very favorably with those for other years. See also the paragraph below, which refers to publications of the United States Bureau of Mines.

Johnson, J. E., Jr.—Blast Furnace Construction in America. 415 pp. 1917. McGraw-Hill Book Company, New York. \$4.

This is easily the most important book of the year in ferrous metallurgy, and one of the most important in a decade. It constitutes a very useful work on arrangement and construction, and to some extent on mechanical features of operation. Deals authoritatively not only with construction of the furnace stack, but with boilers and blowing engines, charging devices, stoves, gas washing, handling of iron and cinder and installation of auxiliary equipment. Con-

cludes with a chapter on dry blast. Not concerned with metallurgical problems. For this subject see Robert Forsythe's "Blast Furnace and the Manufacture of Pig Iron," 1908.

Morgan, J. J.—Blast Furnace Practice. Ed. 2. Charles Griffin, London. 1917. Two shillings.

Iron and Steel.

Bullens, Denison K.—Steel and Its Heat Treatment. 431 pp. 1916. John Wiley & Sons, N. Y. \$3.75.

Practical work with some scientific explanation of processes.

Edwards, Charles A.—Physico-Chemical Properties of Steel. 229 pp. J. B. Lippincott Company, Philadelphia. \$3.75.

Constitution of iron carbon alloys and some special steels. Concise treatment with thorough citation of references.

Everitt, W. E.—Scientific Methods of Tempering Steel. 1917. Author, 727 Belmont Place, Seattle, Wash. \$5.

Fay, Henry—Microscopic Examination of Steel. 18 pp. 55 plates. John Wiley & Sons, New York. (Wiley engineering series.) \$1.25.

Interpretation of metallographic work, primarily for inspectors of ordnance material. Pamphlet originally published by the Ordnance Department, U. S. A., embodying results of work at Watertown Arsenal.

Harbord, Frank William, and Hall, J. W.—Metallurgy of Steel. Ed. 5, rev., 2 vols., 933 pp. 1916. J. B. Lippincott Company, Philadelphia. \$12.50.

Not greatly changed from the previous edition in 1911, but has some additional material. Remains the best general work in English and is without a rival in the mechanical treatment of steel.

International Engineering Congress, San Francisco, 1915—Transactions, 1916. V. 10. Metallurgy. 498 pp. Printed by Neal Publishing Company, San Francisco.

A considerable part of the volume is devoted to problems in ferrous metallurgy, including duplexing, casehardening, alloy steels, ingot piping, iron and steel castings and metallography.

Joseph, P. E.—Iron. 1916-1917. 1916. University of Arizona (Bulletin 43).

Oberg, Erik—Heat-Treatment of Steel. 278 pp. 1917. Industrial Press, New York.

A reprint of the 1914 edition.

Spring, L. W.—Story of Iron and Steel. 358 pp. 1917. F. A. Stokes Company, New York. \$2.50.

Popular descriptive work with numerous illustrations. As an elementary outline it should be of interest to beginners in the steel industry. Author is a steel-works chemist, and his book, though popular, is reliable.

Tiemann, H. P.—Iron and Steel. 354 pp. 1917. McGraw-Hill Book Company, New York. \$3.

A concise encyclopedic dictionary defining all technical and trade terms used in ferrous metallurgy. Processes are outlined briefly but succinctly. A valuable book, the only one of its kind. This is a reprint of the 1910 edition, but a revision is promised at an early date.

United States Steel Corporation—Story of Steel. 63 pp. 1917. United States Steel Corporation, Bureau of Safety, Sanitation and Welfare, New York. (Bul. No. 6.)

Western Spring & Axle Co., Cincinnati—The West-

ern's steel book; a handy reference book for the automobile engineer; edited by E. C. Arndts. 1917.

Contains bibliographies on alloy steels, heat treatment, etc. Contains appendix "Report of Committee 53 of the International Association for Testing Materials, on the nomenclature of the microscopic substances and structures of steel and cast iron." An attractive book outlining history and present practice in the field of ferrous metallurgy. Non-technical.

Foundry and Forge Practice.

Of the few recent works on iron and steel foundries. Moldenke's, mentioned below, is the most important.

The Technology Department of the Carnegie Library, of Pittsburgh, has just published a bibliography of "Sand, Its Occurrence, Properties and Uses." This list includes references to more than 100 articles on the properties and uses of foundry sands.

Gray, Burton L., ed.—Foundry Work; a practical handbook on standard foundry practice, including hand and machine molding, cast iron, malleable iron, steel and brass castings, foundry management, etc.; revised. 196 pp. 1916. American Technical Society, Chicago. \$1.

Elementary work describing practical methods. Very fully illustrated.

Moldenke, R. G. G.—Principles of Iron Founding. 517 pp. 1917. McGraw-Hill Book Company. \$4.

A comprehensive work by an authority on the subject. Has established a high standard and will probably remain for some time the most valuable work of its kind.

Payne, D. W.—Founder's Manual. 676 pp. 1917. D. Van Nostrand Company, New York. \$4.

Valuable compilation, giving much information on the problems of foundry management.

Schwarzkooff, Ernst—Plain and Ornamental Forging. 267 pp. 1916. John Wiley & Sons, New York. \$1.50.

Elementary text-book for vocational and industrial schools. Many good illustrations.

Statistics.

Several of the well-known metallurgical annuals, though primarily statistical, include also valuable reviews of technical progress.

American Iron and Steel Institute—Annual Statistical Report for 1916. 96 pp. 1917. New York.

"Ironmonger"—Metal market year book for 1917. The Ironmonger, London. Three shillings, 6 d.

Metal production and trade with considerable general information.

Metal Statistics—Ed. 10. 384 pp. 1917. American Metal Market Company, New York.

Production and prices of ferrous and nonferrous metals.

The Mineral Industry During 1916—939 pp. 1917. \$10.

"Iron and Steel," pp. 390-436.

United States Geological Survey—Mineral Resources of the United States. 1915. Pt. 1, Metals. 1,000 pp. 1917. Washington. Free.

"Iron Ore, Pig Iron, and Steel," pp. 279-341. Bibliography of Federal and State survey publications on iron ores, pp. 337-341.

The tardy appearance of the annual volume is somewhat compensated for by the fact that the separate re-

ports on individual metals and minerals can be obtained some time in advance.

Miscellaneous.

The following works include directories and a few miscellaneous works, selected from the many technical books of the year, because they contain material of direct interest to steel men.

Annual Chemical Directory of the United States, 1917—(First annual issue.) 305 pp. Williams & Wilkins Co., Baltimore. \$5. 1917, ed. by B. F. Lovelace.

Contains bibliographies. Directories of manufacturers, professional chemists, laboratories, colleges, experiment stations, Federal and State officials, societies, books and journals. Many of these lists cover also the foreign industry. The term "chemical" is so broadly interpreted that the directory is a reference work of real value in all branches of the chemical and allied industries.

Battle, John Rome—Lubricating engineer's handbook; a reference book of data, tables and general information for the use of lubricating engineers, oil salesmen, operating engineers, mill and power plant superintendents and machinery designers, etc. 333 pp. 1916. J. B. Lippincott Company, Philadelphia.

Contains little theory, but gives practical information in regard to lubrication of many kinds of machinery; also deals briefly with lubricants for cutting and threading tools and for wire drawing. Has a brief chapter on lubrication in rolling mills.

Brown, Harold W.—Electrical Equipment. 229 pp. 1917. McGraw-Hill Book Company, New York. \$2.

Confined to the selection and arrangement of electric equipment for shops and industrial plants. Useful book; the only one of its kind.

Cooper, G. Stanley—By-Product Coking. 174 pp. 1917. Benn Brothers, Ltd., London. \$3.

Mainly descriptive of British procedure. Not highly technical.

Elliott, Thomas J.—Elliott's Weights of Steel. For engineers, architects, contractors, builders, steel manufacturers and all users of rolled steel. 662 pp. 1916. Penton Publishing Company, Cleveland. \$20.

"The purpose of this collection of tables is to enable one to find the weight of a single piece of any section of rolled steel without having to perform the operation of multiplication."—*Engineering News*, January 18, 1917. p. 107.

Hirschberg, Charles A.—Compressed Air for the Metal Worker. 321 pp. 1917. Clark Book Company, New York. \$3.

Chapters on applications of compressed air in the foundry and machine shop.

McWane, R. C.—Pipe and the Public Welfare. 165 pp. 1917. Stirling Press, New York. \$1.

Methods of manufacturing cast iron, wrought iron, and steel pipe, information on the deterioration of metal pipe, and relative merits of wrought and cast iron pipe.

Polk & Co., R. L.—National Iron and Steel Blue Book. Ed. 5. 588 pp. 1917. \$10.

A directory of the iron and steel industry. Revision of "Iron and Steel Coal and Coke Blue Book."

Richards, Joseph W.—Metallurgical Calculations; Pt. I. Chemical and thermal principles. Ed. 4. 228 pp. 1917. McGraw-Hill Book Company, New York. \$2.

Scott, Wilfred Welday, and others, ed.—Standard Methods of Chemical Analysis. 864 pp. D. Van Nostrand Company, New York. \$6.

Extensive compilation of selected methods of technical analysis, constituting a useful reference work for the steel works chemist.

Stobbs, Thomas—Stobbs' Wire and Sheet Gage Tables and Metal Calculator. 95 pp. E. & F. N. Spon, London. \$1.25.

Gage tables in English, metric and foreign sizes.

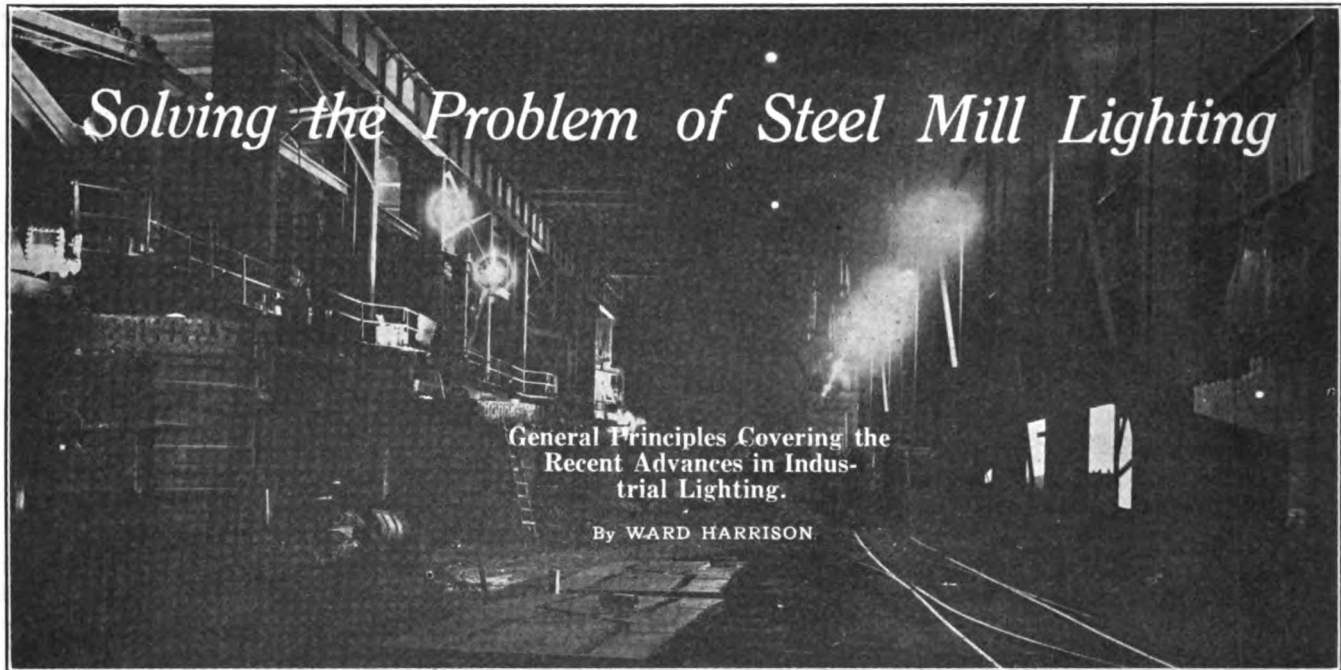
United States Steel Corporation—Methods for the Commercial Sampling and Analysis of Coal, Coke and By-Products. 91 pp. 1916. The Corporation, Pittsburgh. \$1.50.

Among the publications of the United States Bureau of Mines during the year are several of interest to steel men. The "Yearbook" of the bureau for 1916, outlines the metallurgical investigations undertaken, including metal corrosion, slag studies and safety in the iron and steel industry. In the latter field the bureau's most important publication during 1917 is Bulletin 130, "Blast-Furnace Breakouts, Explosions and Slips and Methods of Prevention." 280 pp., by F. H. Willcox. This is complementary to two previous works by the same author, "Asphyxiation from Blast-Furnace Gas," and "Safe Practice at Blast Furnaces," published as Technical Paper 173.

"Coke-Oven Accidents in the United States During 1916," by A. H. Fay, may also be of interest. The bureau announces a popular work, the "Story of Iron," for early publication.

The American Society for Testing Materials has just issued the 1917 "Proceedings," v. 17, in two parts of 875 and 675 pages, respectively. Part I contains numerous tests and specifications for cast, wrought, and malleable iron, for steel from the ingot to the finished product in various commercial forms, and for allied materials, such as refractories, which are of interest to the steel worker. Part II includes several technical papers dealing with such subjects as the following: "Influence of Various Elements in Alloy Steels; Annealing Temperatures; and Magnetic Analysis in the Study of Steel Products."

The "Journal" of the Iron and Steel Institute remains as heretofore, the one important review of the current technical literature of ferrous metallurgy. This "Journal" contains many original papers, and is extremely valuable for reference by reason of the abstracts of recent papers in all languages on ferrous metallurgy. The abstracts or summaries are well prepared and in each case reference is made to the original paper. The volumes issued during the past year are Vol. 94, in two parts, covering the last half of 1916; and Vol. 95, covering the first half of 1917. Despite the decrease in foreign literature, Vol. 95 abstracts some 25 articles on rolling-mill and forge shop practice. The "Journal" is published by the institute, 28 Victoria street, London, at 16 shillings a volume.



PART I.



WARD HARRISON.

RECENT progress in industrial lighting has been marked by three principal trends of development:

First—The general employment of exterior lighting about industrial plants for protective purposes.

Second—The movement in the case of incandescent lighting systems toward greater economy and reliability of operation through discontinuing

the use of 220-volt lamps in favor of those of 105-125-volt class.

Third—And, most far-reaching, the growing appreciation of and demand for more effective interior illumination, i. e., lighting high in quality as well as sufficient in quantity.

Protective Lighting.

There are certain general principles of illumination that must be observed in this as well as in other fields of lighting, regardless of the type of installation that is to be used. An object is seen in detail by the light which comes from it to the eye and not by that which comes direct from the light source to the eye. The aim, therefore, is to throw the light upon the object and to have as little as possible of the light coming direct from the source to the eye, for a bright light in the field of vision makes it difficult to see any object of decidedly lower brilliancy; as, for example, a man dressed in dark clothing. An object is often discovered, however, in silhouette, i. e., by means of light coming to the observer, not from the object, but from a location beyond the object.

Glare is to be avoided. This means the removal from the field of vision of light sources extremely bright with respect to their surroundings. Glare is best overcome in the case of protective lighting by mounting the units at a sufficient height to bring them above the ordinary angle of vision and by shading the lamps with suitable reflectors. In any form of emergency lighting the installation is considered as temporary, there is likely to be a tendency to mount bare lamps on any convenient poles that happen to be available, without due thought of the illumination results of such an installation.

The principal types of accessories used with Mazda lamps in protective lighting are; first, porcelain enamel reflectors, either dome or angle, which are designed to light a limited area in the immediate vicinity of the source; second, refractor units which give a symmetrical distribution of light about a vertical axis but are designed to give a somewhat greater spread than ordinary reflectors; and, third, flood lighting projectors which throw a beam of light 30 deg. or less in width and are therefore suited to lighting objects at considerable distances from the source. Diagrammatic sketches of units used to obtain these types of light distribution are shown in Fig. 1. Attention is called to the fact that the distribution curves in this chart are not plotted to the same scale and, hence, are comparable in shape only.

Plants located in outlying districts and surrounded by an expanse of unoccupied land, as is the case with most large mills, afford a considerable choice as to the type of lighting system to be used. The usual procedure in such cases is to provide a ring or zone of light completely surrounding the plant and, with this zone established, the need for lighting the exterior of

each building is reduced. In fact, it is usually sufficient, under these circumstances, simply to provide sufficient light in alleys and yards to enable the guards to make their periodic inspections.

Zone lighting in a common form consists of a series of lamp standards at a height and spacing depending upon the type of reflector chosen. If dome reflectors are used, the units should be mounted at a height of not less than 15 feet above the ground; the spacing of units with this type of reflector should not exceed three times the mounting height. A 100-watt lamp will generally be satisfactory at a mounting height of 15 feet. Obviously by increasing the height of the lamp standard the use of fewer units at wider spacing is permissible. However the light is then distributed over a proportionately wider zone, hence, for the same brightness of illumination, the total wattage of the

greater concentration necessary in other applications illuminate too narrow a zone at ordinary mounting heights. The guard should patrol the plant in the same general direction as that in which the light is projected, as he is then spared the necessity of having to face into the beam of the bright light sources. It must be borne in mind that while the guard will ordinarily not be in the brightly lighted zone, occasion may arise which will necessitate his not only being in the lighted zone, but, also perhaps, his having to face in the general direction from which the light is coming; hence, the higher the units are mounted, the better from this standpoint. Units of the 400-watt size spaced at intervals of 200 feet and mounted 15 feet or higher above the ground, should prove satisfactory. An installation of this type often represents the least

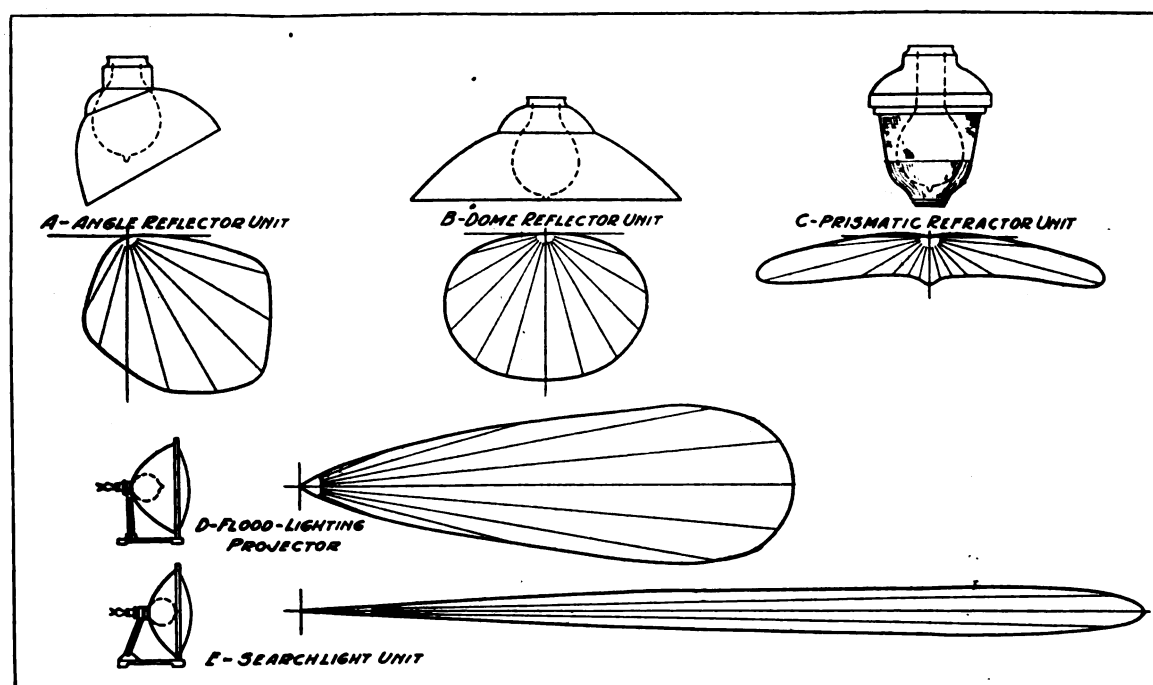


Fig. 1—Showing light distribution from various types of lights

lamps in the installation will necessarily be increased. If refractor units are decided upon, the minimum mounting height should be 20 feet and the spacing not more than 54 times the mounting height. Lamps of 300 to 500 watts are most desirable. The wider distribution of the refractor unit is of advantage not only because it permits wider spacing between units, but also, it will be observed, because a wider strip of ground is illuminated effectively.

A type of zone lighting which is being employed effectively at present and with the important advantage of extreme simplicity of installation to recommend it, is that using flood-lighting units. As will be noted in Fig. 1, reflectors of this type have a very concentrated distribution. For zone lighting, a reflector having a beam spread of from 25 to 30 deg. is most desirable. Many projectors designed for the

expensive system of protective lighting which may be installed. Hence, as in previous cases, there should, of course, be sufficient lighting in and about the plant as a whole to provide for effective patrolling.

Another method in which flood-lighting units may be made to advantage is by mounting them singly or in groups upon specially constructed towers or vantage points of buildings at various places about works to flood-light the surrounding grounds. If the units are mounted at a considerable height, say from 30 or 50 feet, the matter of glare as affecting persons approaching the plant will not be serious.

From the standpoint of economical electrical distribution, where the area to be covered is extensive, a series circuit has advantages which entitle it to consideration. Series systems employ lamps of the street

series type and require the installation of constant current apparatus.

Converting 220-Volt Circuits to 110-Volts.

As the voltage for which electrical apparatus is designed increases beyond certain limits, the difficulties of manufacture are multiplied. In some cases, the difference may not be seriously felt until a potential of several thousand volts is reached. With incandescent lamps, however, the limit comes much earlier; in fact, it has not been found possible as yet, to manufacture lamps for 220-volt circuits which are as satisfactory as those of the 110-volt class. Lamps of the 220-volt class have lower efficiency, a less uniform performance and a higher cost of manufacture than those of the standard voltage range. Their use is, therefore, to be avoided whenever possible.

Where 220 volts only is available, the practice of burning two lamps of the 110-volt class across 220-volt lines has met with considerable favor. Under these circumstances, however, slightly less than normal life is to be expected from the lamps, for although two new lamps usually operate satisfactorily in series, one lamp naturally fails sooner than the other, and when a replacement is made, the resistance of the two lamps will be higher than that of two new lamps and less than that of two old ones, for the resistance of lamps increases with burning. Hence, the new lamp will receive slightly less than normal current and will give less than normal candle-power, while the old lamp will be forced to carry a somewhat heavier current than it would normally carry at that period of its life and will, therefore, fail earlier than it otherwise would.

A more serious disadvantage of operating two lamps in series is that the failure of either lamp means the outage of both; thus a relatively large area is left without sufficient light and the time of several persons may be lost while the defective lamp is being located and the replacement made. Obviously, in industrial plants and shops, accident risk under these conditions is increased over that when only one lamp is out.

Because of these factors, in the great majority of plants where 220-250-volt lamps are now used, the most satisfactory and economical lighting results are to be secured by providing 110-volt potential for the lamps by placing a balancer between the 220-volt lighting feeders and running a third, or neutral wire to the main distributing points. The purpose of the balancer is to maintain equal voltage on the two sides of the three-wire circuit despite unequal loading. For alternating-current circuits, a simple balancer coil suffices: for direct current, a small mechanically coupled shunt or compound-wound motor set is commonly used.

With either a motor-generator set, or a balancer coil, the current which the heavily loaded feeder carries in excess of that flowing through the lightly loaded

side must be carried by the neutral wire. This neutral current divides at the motor-generator set, half of it, plus the current necessary to offset the losses of the generator, flowing through the motor and the remainder flowing through the generator. If it is considered advisable to protect the balancer against possible overload, a circuit-breaker may be arranged to open both sides of the circuit between the balancer and the source of supply, or to open all three circuits between the balance and the lamp load; the precaution taken to guard against a break in the neutral of any three-wire system should, of course, be applied.

Since the current which the balancer must carry is determined by the degree of unbalancing, the capacity of the apparatus required in any given case depends upon the magnitude of the lighting load and upon how nearly the conditions of installation will allow the circuits in the panel boxes to be made to balance. Obviously, the greater the number of properly connected circuits, the smaller the chance for serious unbalancing to occur. In practice, the size of the balancer installed ranges from about 10 per cent of the total connected lighting load to 20 or even 25 per cent, depending upon the size of the load and upon how well the circuits may be divided. The capacity of the balancer set as used here is in terms of the current flowing in either machine multiplied by the total impressed voltage of 220-250 volts, or what is the same thing, the current flowing in the neutral multiplied by half the impressed voltage.

At the time the balancer is installed, an excellent opportunity is afforded to make another decided improvement in the service by separating the power and lighting circuits, if this has not already been done. Not only are fluctuations in voltage caused by the starting of motors or by the sudden shifting of heavy loads confined mainly to the power circuit and their effect upon lamp performance thus reduced, but trouble in the power circuit is less likely to cut off the illumination of the plant at a moment when light is urgently needed.

Space does not permit of a comparison between the operating cost of 110 and 220-volt lighting systems; however, those engineers who have desired to avail themselves of the more uniform performance and greater reliability of 110-volt lamps but have hesitated to change over on account of the cost of requiring and equipment, will be interested to know that in most cases this entire expense is offset by the reduced cost of lamp renewals and energy during the first year or year and a half of operation. It should be borne in mind also, that where the wattage of the lamps is kept the same as before, the illumination will be increased by from 10 to 20 per cent, an improvement which is usually very acceptable in view of the general rise in the standard of illumination.

In the next installment more effective interior lighting will be considered.

Electrical Cleaning of Blast Furnace Gas

Cottrell Electrical Precipitation Process Offers Means of Hot-Dry Primary Gas Cleaning—Results of Investigation at Steel Plant—Principles of Electrical Precipitation.

By H. D. EGBERT,
Research Corporation.

When internal combustion engines operating on blast furnace gas as fuel first came to be used as a source of power in iron and steel plants, the necessity for a thorough cleaning of the gas at once became apparent, and to meet this need a great variety of cleaning systems have been developed. It was not long before the desirability of cleaning that portion of the blast furnace gases burned in the hot blast stoves and under steam boilers became also very apparent, so that to-day the modern blast furnace plant is usually equipped with two cleaning systems known as the primary and secondary systems. After the gas is passed through the primary cleaning system a portion of it is burned in the hot blast stoves and under steam boilers and the remainder is cleaned in the secondary cleaning system, after which it is ready for use in the gas engines.

By far the greater majority of the cleaning systems in use to-day are of the wet washing type in which water is employed in a variety of ways as the agent for removing from the gases the suspended matter carried in suspension therein. One of the features inherent in a wet washing system is the cooling of the gas being cleaned. In a secondary cleaning system this is not an objectionable feature, inasmuch as the gases must be cooled before being used in the engines. In the primary cleaning of the gases, however, especially as regards that portion burned in stoves and under boilers, the cooling of the gas is not desirable because of the fact that a considerable amount of available useful heat is thus lost, due to the removal of the sensible heat in the gases when a wet washing system is employed.

In a paper by Messrs. Linn Bradley, H. D. Egbert, and W. W. Strong, entitled "Dry Hot Versus Cold Wet Blast Furnace Gas Cleaning," presented at the February, 1917, meeting of the American Institute of Mining Engineers, and published in the February, 1917, issue of the *Transactions*, calculations are described and curves presented showing the saving of heat that can be accomplished by the dry cleaning of blast furnace gases as compared with the use of cold wet cleaning methods.

In the case of a typical blast furnace top gas having a moisture content of 25 grains per cubic foot, calculated at standard conditions, and a temperature at the entrance to the primary cleaning system of 500 deg. F. it can be shown from the calculations and curves given in this paper that by the use of a hot dry cleaning method as compared to a cold wet process, approximately 110 B.t.u. per pound of top gas can be saved and applied to useful

work in the hot blast stoves. This saving, furthermore, is the net saving which can be realized after due deduction has been made for the heat carried out with the stove exit gases by the moisture content of the raw top gas, which moisture is largely removed when a cold, wet method of cleaning is employed.

In this paper, furthermore, the importance of keeping down the amount of excess air used in burning the gases in the stoves is also shown and the fact is established that when the moisture content of the gas is not too high the conservation of the sensible heat energy in the gas as accomplished by a hot dry method of cleaning permits of high temperatures in the stove.

In further consideration of the hot dry method for the primary cleaning of blast furnace gas as compared to the cold wet method, it might be mentioned that in some places large quantities of water for use in wet scrubbers are difficult and expensive to obtain, and a further difficulty is sometimes encountered, due to the fact that when large quantities of water are used for cleaning purposes the resultant pollution of the nearby streams due to the inflow of dirty water from the scrubbers constitutes a nuisance which in many cases is prohibited by the Federal or State authorities. Both of the above difficulties are obviated when the hot dry method of cleaning the gases is employed.

Because of the above facts it has been recognized that the hot dry primary cleaning of blast furnace gas is very desirable, and since this is the case it is not surprising that considerable attention should have been directed of late to the Cottrell electrical precipitation process as offering a most available and satisfactory means of hot dry primary gas cleaning.

Interest in the use of the Cottrell processes as a means of cleaning the blast furnace gas has been further augmented by the fact that the dust and fume carried by these gases often contains valuable materials, such as compounds of zinc, lead, manganese and especially potash, which might be easily recoverable through the use of a dry hot cleaning process. During the past four years a great stimulus has been given to the production of potash in this country, due to the curtailing of the foreign potash supply because of the war. Prior to the war the Cottrell processes had been successfully applied to the collection and recovery of the dust and fume carried by the gases coming from rotary kilns in plants manufacturing Portland cement, and it was found that in many cases the collected fume con-

tained considerable quantities of water-soluble potash compounds. As a result the electrical precipitation processes have been installed during the past few years in a number of large cement plants, notably at Hagerstown, Md., and at Riverside, Cal., for the primary purpose of recovering the potash compounds carried by the dust and fume given off by the kilns at these plants. These installations have resulted in a considerable addition to the potash resources of the country, and as further installations are made on other cement plants, the amount of available potash recovered will steadily increase. As an indication of what is being accomplished in this line, it has been

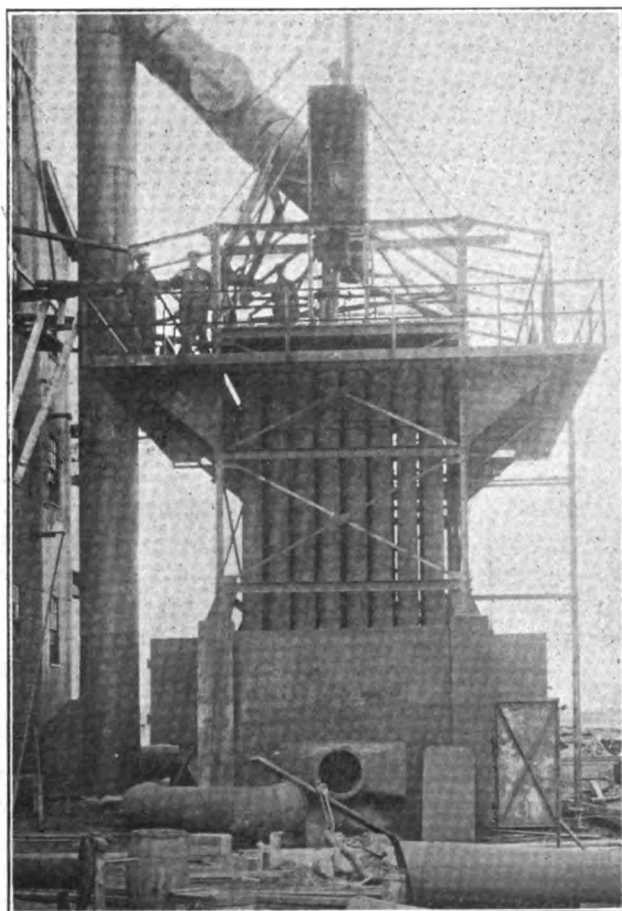


Fig. 1—Cottrell electrical precipitation installation handling gases from a Dwight-Lloyd sintering machine. The photograph was taken during the construction and shows the arrangement of the precipitation, method of connecting to existing floor system and stack.

stated in a recent technical publication that the Cottrell precipitation installation at Hagerstown, Md., is recovering 20 tons per day, averaging 12 per cent available K_2O .

It has long been known that certain of the raw materials charged to the blast furnaces contain appreciable amounts of potash. Especially is this true in connection with blast furnaces in the southern districts of the United States, where iron ores running as high as 2 per cent potash and over are frequently found. It has further been proved by many analyses

that the dust and fume carried by the gases coming from blast furnaces running on ores of this character contain considerable amounts of available potash, and there seems to be no reason why this potash should not also be reclaimed in the same way as that carried by the fumes and dust from kilns in cement plants.

In February of this year a very interesting article entitled, "Potash as a By-Product from the Blast Furnace," was presented before the American Institute of Mining Engineers by R. J. Wysor, superintendent of blast furnaces of the Bethlehem Steel Company. This paper shows very clearly some of the possible potash recoveries obtainable from the dust and fume given off from blast furnaces using ores containing approximately .28 per cent K_2O , a flux containing from .36 to .82 per cent K_2O , and a coke containing approximately .28 per cent K_2O . Mr. Wysor shows that the total amount of potash charged to a furnace running on materials having potash contents as stated above, averages about 22.4 pounds per ton of pig iron produced, of which approximately 16 pounds are recoverable by a hot-dry cleaning process. Mr. Wysor's paper further shows in a very graphic and interesting manner the deleterious effect upon the stove brickwork by the potash and other alkali compounds in the fume and dust carried by the gases, and the possible savings and improvement of operation which may be obtained by a thorough cleaning of the gases prior to their combustion in the stoves, is clearly shown.

The reader is further referred to in a paper by Charles Catlett entitled, "The Blast Furnace as a Potash Producer," appearing in the issue of the "Manufacturers' Record" under date of May 11, 1916, and to another paper by John Sharshall Grasty entitled, "Southern Iron Ores as a Source of Potash," appearing in the September 14, 1916, issue of the "Manufacturers' Record." These articles discuss in a very interesting way the possibilities in potash recovery offered by furnaces in the southern district treating potash-bearing iron ores.

It will be evident on slight reflection, that a hot dry method of blast furnace gas cleaning is decidedly preferable to a cold-wet method when the question of the recovery of the dust and fume is under consideration. The difficulty of handling large amounts of water and sludge from wet washing systems and the trouble incidental to recovering therefrom the valuable potash compounds, will at once be evident. The Cottrell precipitation system on the other hand offers a means of recovering the dust and fume from blast furnace gases in a dry form from which the potash values can be extracted without undue expense or difficulty. Indeed, it will be possible to sell this dust to fertilizer manufacturers as it comes from the precipitators should the blast furnace operator desire not to extract the potash content therefrom himself.

During the past 18 months the Research Corpora-

tion has been conducting more or less continuously a series of tests with the Cottrell precipitation processes on cleaning blast furnace gases at a large iron and steel plant in the eastern part of the country. These tests have conclusively demonstrated that electrical precipitation can be successfully applied to the cleaning of iron blast furnace gas, and have further yielded a mass of data upon which to base the design of a large precipitation installation for handling all the gases from one furnace, or a considerable portion of such gases.

The precipitator with which these experiments were run was capable of handling up to about 3 per cent of the total volume of gas given off by one 500-ton furnace or approximately 2,400 cubic feet of gas per minute at 300 deg. F. It was found possible to clean the gas in one treatment in an electrical precipitator, from a dust content of three grains per cubic foot calculated at standard conditions, to a dust content as low as .05 grains per cubic foot calculated at standard conditions. The collected dust and fume showed a potash content of over 10 per cent available potash. Continuous runs lasting for several days were frequently made without serious difficulty, and during such runs satisfactory clearance of the dust and fume was maintained.

When it is considered that these results were obtained with a precipitation in which many of the refinements which are installed in a commercial installation were lacking and in which certain features, notably those of insulation were of a rather makeshift character, it will be seen that there is every ground for the statement that the Cottrell processes can be successfully applied at the present time to the primary cleaning of iron blast furnace gases.

The next step in connection with this use of the electrical precipitation process will be the construction of an installation of sufficient size to clean all the gases from one blast furnace, or perhaps of sufficient size to clean the gases required for combustion in one or more stoves, and it is hoped that such an installation will be under way in the very near future.

Principles of Electrical Precipitation.

Imagine a body so highly charged with electricity as to ionize the gas surrounding it, brought near to a particle so suspended as to be able to move freely in any direction. As the charged body approaches the particle, the latter will receive a charge of the same sign as that of the charged body and will be violently repelled from it. This is exactly what takes place in an electrical precipitator, except that the charged body is fixed and the particles are brought to it.

The precipitator in its simplest form consists of two sets of electrodes. One set, known as discharge electrodes, are of such form as to facilitate an electric discharge from their surface, as for instance, a wire or a light chain, while the other set, known as the col-

lecting electrodes, are of such shape as to prevent as far as possible, any discharge from their surface, as for instance, a flat plate or a pipe. These electrodes are so arranged in the precipitator that the different types oppose each other and between them a silent or glow discharge is maintained by impressing on the discharge electrode a unidirectional current of high potential. In practice the collecting electrodes are grounded for reasons of convenience and safety. A simple form of precipitator, for example consists of a grounded pipe along the central axis of which is placed a wire connected to a source of high potential unidirectional electricity.

The gases carrying the suspended solid or liquid particles, which are to be removed, are passed between the discharge and collecting electrodes. During pass-

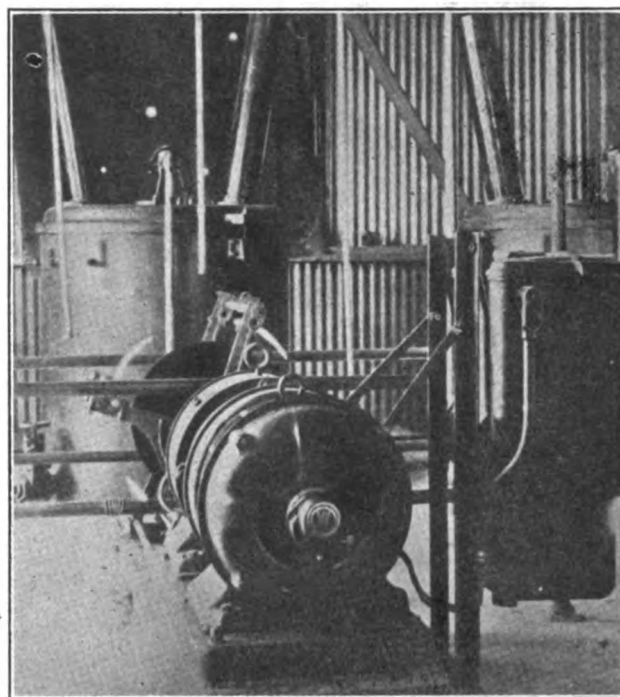


Fig. 2—A typical set of electrical equipment for use with the Cottrell precipitation installation.

age the particles are charged and are driven away from the discharge electrodes and over to the collecting electrodes, upon which they are deposited. The gases are unaffected and pass on out of the precipitator chamber.

It will be evident on slight reflection why high potential alternating current is not used to produce the desired effect. This is due to the fact that in such cases the charge on the electrodes rapidly alternates in sign and the particles of suspended matter are alternately repelled and attracted by the discharge electrode, and consequently tend to remain suspended in the gases. The alternating current does have an agglomerating effect on particles, which is particularly noticeable when these particles are liquid in their nature. The glow emanating from the discharge elec-

trodes is known as the corona and is an evidence of the intense ionization of the gases surrounding the electrode. For any given gas there is in all cases a rather definite potential at which a visible corona begins to form, depending upon the character of the discharge electrode and the distance or gap space between it and the collecting electrode. In general, if simultaneous readings are taken of the current flowing in the high-tension circuit and of the potential difference between the electrodes, it is noticed that the current will increase in proportion with increase in potential until the point of corona formation is reached. At this point the current begins to increase much more rapidly with each increase in potential and continues to do so until breakdown or sparkover voltage is attained.

It has been found that the most effective precipitat-

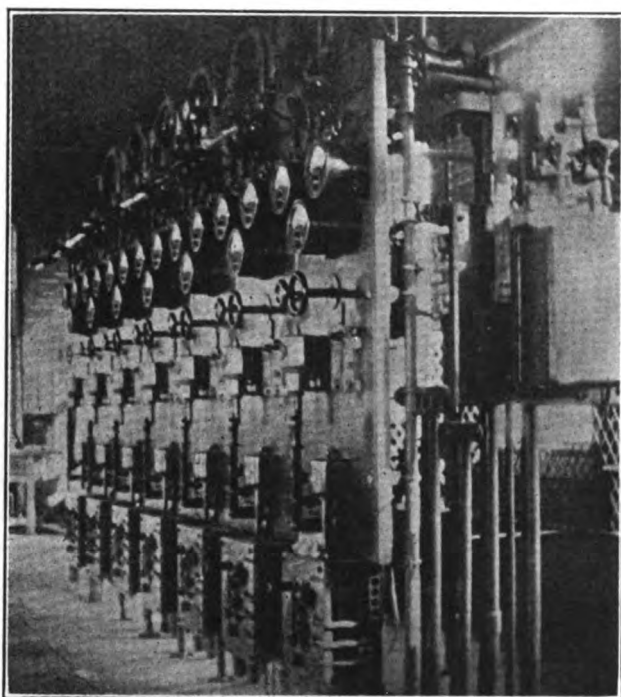


Fig. 3—Switchboard panels for use with a large installation.

ing action is not obtained unless the potential difference between the electrodes is sufficient to produce a corona discharge.

In the early stages of electrical precipitation work the voltages in use were much lower than those employed nowadays, and it was found necessary to use special types of discharge electrodes designed to produce the desired corona discharge at comparatively low potentials. Thus in the first precipitators wire wound with asbestos twine and micanite strips with serrated edges will be found in use for this purpose. The present use of higher potentials has done away with the necessity of employing this means of producing the corona and today wires, rods, chains and metal strips are successfully used as discharge electrodes.

It is interesting to notice in this connection that

the corona discharge, which is so useful in precepitation work, is the very thing which the high tension transmission engineer endeavors in every way to prevent, because to him it represents a distinct loss of power, whereas in the case of electrical precipitation this power is usefully employed in removing the suspended matter from the gas which is to be cleaned.

The potential employed in a given precipitator depends upon the size and type of discharge electrode used, the gap distance between the discharge and collecting electrodes and the temperature and other characteristics of the gases being handled. It will doubtless be evident, from the principles underlying the phenomena of electrical precipitation, that there is a definite relation between the velocity of the gases through the precipitator and the length of the path between the electrodes. In other words, the particles must be under the influence of the electric field for a period of time in order to secure satisfactory removal of these particles from gases. The length of this period depends to a considerable extent upon the character of the particles to be precipitated. If the particles are light, dry and very finely divided, a longer time will be required than if they are relatively coarse or of a liquid or sticky nature. The length or height of the precipitator is, of course, limited by the considerations of practicability and cost, and consequently there is in every case a definite limit to the gas velocity through the precipitator at which complete removal of the suspended particles can be accomplished. In practice it is common to use collecting electrode pipes ranging from 6 to 12 inches in diameter and from 8 to 15 feet in length, and gas velocities ranging from 4 to 15 feet per second, depending upon the factors above mentioned.

When conditions warrant it is customary to build a precipitation installation in sections or units. Such an arrangement costs somewhat more than does one unit, but it has the advantage of allowing considerable flexibility in the operation of the processes and permits of a closing down of a portion of the installation for repairs or cleaning without involving the removal of the entire precipitator from service. Where the volume of gas to be treated is liable to vary at different periods of time this sectional arrangement of an installation has a further advantage of permitting a saving in power by shutting down certain sections of the precipitator at a time when the maximum volume of gas does not have to be treated.

The question is often asked as to how the precipitated material is removed from the collecting electrodes. If this material is liquid in nature it will of course trickle down the surface of the electrode and will drop into a suitable container provided for the purpose beneath the precipitator. If the collected material is dry it is often necessary to dislodge it from the electrodes by mechanical means. Usually the cleaning is accomplished by striking or rapping

the pipes or plates, whereupon the collected material falls into hoppers placed to receive it. In some cases it is also necessary to clean the discharge electrodes occasionally. When such a condition is anticipated, provision is made for rapping the framework which supports the electrodes, a procedure which serves to dislodge any collected material.

The power required to operate a precipitator is usually small and depends, of course, on its size. For instance, a precipitator to handle 10,000 cubic feet of gas per minute will usually require from 7 to 10 kw. The power consumption is governed by the number of electrodes and their length, type and size, as well as by the characteristics of the gases to be handled, as regards temperature, conductivity, etc.

The method of obtaining unidirectional high potential current necessary for use in the precipitator will doubtless be of interest and can be briefly explained as follows:

If low tension alternating current of any commercial frequency is available at the plant in which the installation is made, all that is required in the way of electrical equipment is a transformer of proper capacity for stepping up the low-tension electric current to the required potential for use in the precipitator; a rectifier for changing the high potential alternating current into a high potential unidirectional current, and a small switchboard panel with the necessary instruments, circuit breaker, switches, rheostat, etc., mounted upon it. In case a mechanical rectifier is employed, a 2 to 3 hp. synchronous motor is required for driving the rectifier in synchronism with the alternating current supply.

If only dc. is available at the plant in question, it is necessary to install a small motor-generator set or rotary convertor for the purpose of producing the low-tension alternating current. The remainder of the equipment is the same as in the previous case, with the exception that the rectifier, if of the mechanical type, instead of being provided with a separate synchronous driving motor, is driven directly by the motor-generator set or rotary, as the case may be.

During the last year or two a high potential, direct-current generator has been successfully adapted to precipitation work. Although no precipitation installations at present in commercial operation are equipped with this machine, nevertheless it has been extensively tested by the Research Corporation in connection with the Cottrell processes and has proved very satisfactory for the purpose.

The cost of electrical equipment is, of course, dependent upon the size of the precipitator which it is to supply and it is also dependent upon the available power at the plant where the installation is to be made. If a motor-generator set is to be used, the cost of the electrical equipment will be considerably higher than if a synchronous motor could be employed. Some

idea of the cost of electrical equipment may be obtained from the following figures:

A set having a capacity of 10 kw. giving a maximum potential of 75,000 volts and consisting of a transformer, synchronous motor, rectifier and switchboard, may be obtained for about \$1,400. If a motor-generator set were required an equipment of the same capacity would cost approximately \$2,200. The larger the power rating of the transformers and motor-generator units, the lower is the cost per kilowatt of capacity. This is especially true with the transformer, as a great deal of its cost is due to the insulation against the high voltage and this, of course, must be just as effective in a transformer of small kilowatt capacity as in a transformer of large kilowatt capacity. The difficulties involved in continuously rectifying heavy currents make it advisable to keep the power capacity of the electrical sets down to a reasonable figure, and in practice equipments over 25 kw. capacity are seldom used.

Fig. 2 shows a typical set of electrical equipment for use with Cottrell precipitation installations. This consists of a motor-generator set, rectifier, transformer and switchboard panel. As above mentioned, in case a steady supply of alternating current is available at the plant a small synchronous motor can be substituted for the motor-generator set here shown, thus reducing considerably the cost of the electrical equipment.

Fig. 3 shows a set of switchboard panels for use with a large installation of the Cottrell electrical precipitation processes in connection with which several sets of electrical equipment are employed. As shown here, one switchboard panel is provided for use with each set of electrical equipment.

At many blast furnaces, roasting of the ores and concentrates and the formation of a sintered product suitable for use in blast furnaces is accomplished by means of sintering machines of the Dwight-Lloyd type. In this sintering process the metal losses in the dust and fume carried off by the gases are often considerable. Moreover, the gases drawn from the sintering machines often contain considerable free sulphuric acid and at times some elemental sulphur. Because of the frequent presence of these constituents in the fumes and dusts from sintering machine installations, the bag house does not offer a very satisfactory means of recovering the suspended matter carried by these gases, since there is often a rapid destruction of the bags due to the corrosive action of the free acid in the gas, or due to fires caused by the burning of elemental sulphur present in the collected material. The operation of a Cottrell precipitator, however, is not adversely affected by the presence of free acid or elemental sulphur in the gases to be cleaned and it is therefore not surprising to find electrical precipitation being adopted in many plants for the purpose of removing and collecting suspended particles of material.

Progress in Open Hearth Practise Reviewed

Difficulties in Establishing the Basic Open-Hearth Process Related—Danger in Furnaces of Too Great Capacity For Good Steel Making.

By JOHN McCONNELL.



JOHN McCONNELL.

THE writer has been connected with the steel industry since 1882, being at that time connected with the Steel Company of Scotland, which was the first concern to manufacture acid open hearth steel in that country. Most of the skilled men came from Llandore, Wales, where acid open hearth steel had been made for some time previous to this.

The above company had 16 acid open hearth furnaces of 10 to 20 tons capacity operating on the process generally known as the "pig and scrap process," charging 75 per cent pig iron and 25 per cent scrap. The steel made was of excellent quality and was principally used for boiler, firebox and ship plate.

In the early days of making acid open hearth steel, quality was the first requisite, and great care was exercised to check up each heat. Before tapping, both slag and steel were subjected to certain physical tests, the first melter being required to present a sample for test of both slag and steel. The sample slag test had to show a light yellow with a greenish tint. The sample steel test required that specimen flatten out without cracking. If the tests were up to standard the bath was reboiled with from 500 to 1,000 pounds of pig iron to make sure that all of the ore was worked out of the bath. This guarded against the detrimental effects which might result from the first melter having added too much ore and rushed the carbon out too fast, and was a precaution taken to prevent shrinkage cracks in the ingots.

Both bottom and top pouring was used. The bottom-poured ingot gives the best surface but more segregation. The use of two ladles to make the steel more homogeneous was also tried. This method comprised tapping into the first ladle and pouring from this into the second, and then the nozzle to the molds. This worked well and served to make the steel more homogeneous, but it cut down the output so much that it was later discontinued and one ladle was used, pouring direct into the molds.

All ingots were hammered into either billets or slabs for plates, and several methods of heating after stripping were tried in order to get the best results. After stripping, the ingots were put into air-tight pits

and rolled or hammered, using the initial heat. This was discontinued as it was found that the quality of the steel was injured. It has been found that the best method of heating steel ingots for quality is to allow the temperature to fall below the rolling temperature and then to heat up to the required rolling temperature again.

In 1887 the Homestead plant of the Carnegie Steel Company installed four Lash type acid open hearth furnaces of 50 tons' capacity (round furnaces with straight-line flues for checker chambers). Instead of using 75 per cent pig iron and 25 per cent scrap as was the practice in Scotland, they used 30 per cent pig iron and 70 per cent scrap. This was a marked variation from the previous process and there is a great difference of opinion as to the quality of steel made by these two processes. Good steel can be produced by either process. The "pig and scrap process" (75 per cent pig iron and 25 per cent scrap) gives a very good quality of acid open hearth steel when care has been taken to obtain the proper condition of slag, to work all ore out of the bath, and to maintain the right temperature to carry the metal into the moulds. When using the 70 per cent scrap and 30 per cent pig method, the danger comes from a fast working furnace with a sharp cutting flame. This will melt the charge very rapidly and the slag is generally brittle and of a grayish color. Under these conditions the steel is seamy and brittle. Therefore a slow working furnace will always make the best open hearth steel. This is especially true when using high percentages of mild scrap.

Development of Present Basic Open Hearth Process.

In 1888, Mr. Purvise of the Homestead steel works, changed one of the four 50-ton acid open hearth furnaces to a basic furnace, and, while the steel made was low in phosphorus and sulphur, it was also very low in carbon and was not marketed the first year, but was used as scrap in the three acid furnaces, taking the place of the high priced Apollo bloom.

As was naturally expected, a great deal of trouble was experienced with this new process about which little was known. Great credit is due the men who succeeded in making basic open hearth process commercially possible. The principal difficulties at this time were; to "get and hold" the carbon in the steel so that it could be depended on to meet specifications, to handle and pour the metal into the moulds, as it was. To the above charge there is to be added 12 per cent

foamy and piped considerably; and to obtain a satisfactory furnace bottom and banks from the dolomite then in use. Labor costs were very high in this process, inasmuch as all charging was done by hand. The furnace crew consisted of 14 men: one melter, one first helper, one second helper, three stokers, one first, second and third pitman, bottom maker and helper, ladle man and helper, and one crane man.

Methods were gradually discovered and perfected to overcome these difficulties. The introduction of fluor spar for fluxing the limestone and thus getting the proper slag, and the use of powdered coal for re-carburizing in the ladle aided considerably in controlling the carbon in the metal. The use of aluminum as a deoxidizer greatly helped in handling the metal as it made the steel pour well and lie in the moulds without foaming. Fifty per cent ferrosilicon was also introduced and was found to give very beneficial results in producing a steel more sound and more free from blowholes. Austrian magnesite was introduced in place of dolomite bottom and banks, and its durability more than made up for its increased cost. Dolomite was, however, still used for repairing bottom. Another great advancement toward the present-day open hearth was that made by Mr. Wellman, of the Wellman-Seaver-Morgan Company, who introduced the charging machine, and thus cut down the high labor costs. With these difficulties overcome, the basic open hearth process was in a position where it could be depended on to produce steel in the proper condition to meet specifications.

The second basic open hearth furnace was under construction at Homestead when Charles M. Schwab became manager. In the next two years, 14 more basic open hearth furnaces were built, making a total of 16.

The purpose of the basic process at this period was: to increase output, lower the costs per ton produced, and to make a quality of steel that would be as good, if not better, than the acid open hearth steel.

When one recalls the obstacles encountered in 1888 and 1889, at the time of the beginning of basic open hearth process, the present output of 29,000,000 tons of basic steel in 1916 is truly remarkable. When we consider that the quality produced by the basic process is excelled only by that of the crucible and electric processes, only the men connected with the process at the start who can realize the enormity of this growth.

The danger at present is in furnaces of too great capacity. The basic open furnace of 50 tons' capacity has proven beyond a doubt that it can produce the highest quality of open hearth alloy steel.

The writer believes that for making high quality basic open hearth steel the following charge is ideal: 55 per cent scrap, 45 per cent pig iron. Analysis of pig iron to be:

	Per cent
Phosphorus under	.40
Silicon under	1.00
Sulphur under	.05

limestone and 5 per cent manganese. This manganese added with the charge will serve to protect the material from oxidation during the melting period. By adding 1,000 pounds of spiegel to reboil the metal, also 1,000 pounds of burnt lime before adding the final manganese in the bath, and with a slag high in lime and low in oxide of iron, the steel will be low in non-metallic impurities. This addition of manganese in the bath before tapping improves the quality of the steel greatly by cleaning the metal from oxide inclusions. The loss of the manganese is about 20 per cent, but we consider that this loss is more than made up in the quality of steel produced.

The writer believes that the chief factor in obtaining metal low in non-metallic impurities at the completion of the melting is the development of the proper slag. Too much stress cannot be placed on the question of slag, unless the proper slag is produced the metal will not be of the best quality even if every other condition is perfect. I consider the best slag to be one in which the lime is kept comparatively high, with iron oxide comparatively low, and, of course, securing the proper fluidity at the same time. The average lime and iron oxide contents of a number of samples taken from slags on exceptionally good heats show lime 52.8 per cent, ferrous oxide 12.7 per cent. Allowing of sufficient time for this slag to develop is most essential. If the bath of steel is rushed with ore too near the tapping time, the slag will not be low in oxide of iron, and the steel will contain oxides and gaseous impurities. This condition, especially when manganese is added in the ladle with the temperature on the high side, will produce in the ingot small blowholes or gas bubbles near the surface which will form seams in the finished product. On pouring this steel into the molds, the tendency is for it to rise and shrink away from the walls, and, as said before, to form blowholes or gas bubbles at and very near the surface of the ingots. The edges of these holes, more or less in contact with the air, become oxidized and will not weld or close up in rolling, and the result is a finished product that has a solid center but a surface which is seamy.

On the other hand, if the bath of metal is not rushed with ore near the tapping time, small quantities of manganese and spiegel are added, and time is allowed for these to take effect, care being taken at the same time to have the temperature close to good pouring, we will have a slag which will be low in oxide of iron, and the bath will be free from oxide and gases. When this steel is poured, the chances are that it will lie well in the mold, the pure metal will freeze on the sides of the mold, and what impurities are in the steel will be more localized at the center. These ingots will give a good rolling steel as the surface will be solid and whatever blowholes are inside the ingot will not be oxidized, since the edges

will be clean and bright and will readily weld when rolled.

The addition of silicon in the ladle to bring the silicon content in the steel up to .10 to .20 per cent will produce a steel more sound and free from blow-holes, and if we have had the proper slag, temperature of tapping as explained, and now add silicon in the ladle, we will get from 65 to 75 per cent of good solid steel. If we have not had the proper conditions, we will not get anything like this percentage.

Steel with silicon will have a portion below the pipe in the ingot that will be weak. This portion will be about 5 per cent of the ingot. We can easily identify this when hot shearing, as it will show "pulls." When steel is to be put through some very severe operation, such as piercing for seamless tubing or upsetting, about 8 to 10 per cent should be sheared off below the pipe to be sure that this portion has

been removed, and the balance of the ingot is composed of solid homogeneous steel.

The first 200-ton Talbot tilting furnace was built at the Jones & Laughlin Steel Co. of Pittsburgh, Pa., in 1905 and produced over 100 tons of steel per day direct from the hot metal without the use of scrap. The carbon was deoxidized or reduced by the addition of roll scale. After taping 50 tons of steel, the melter added sufficient roll scale to oxidize the bath so that the hot pig iron from the metal mixer, on being poured in, came in contact with the highly oxidized slag. This produced a very violent reaction in throwing off the carbon gases and a great deal of slag with them. This was extremely hard on the furnace lining and roof, but was to a large extent overcome and the life of the furnace brought up to standard practice. The Jones & Laughlin Company were assured of the success of this furnace, and in 1906 built four more 200-ton Talbot furnaces.

First Electric Furnace in South America

Numerous Obstacles are Encountered in Erecting Furnace in Bolivia Due to Difficulty in Securing Equipment, Materials, Supplies—Water Power Used to Generate Electricity in Power Station.

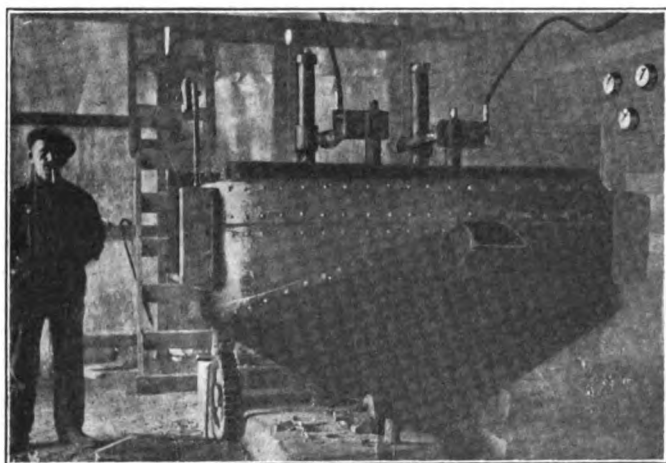
BY RAYMOND S. WILE,

President Wile Electric Furnace Company.

Upon considering the difficulties encountered in obtaining materials in this country, it can readily be realized to what extent these difficulties would be multiplied in a country 6,000 miles away from the source of supply. To the difficulties in obtaining exports, long freight hauls, danger of breakage, chances of theft and high freight

there are two or three small iron foundries in the entire republic steel castings could not be obtained anywhere. There is no gas plant in the country. Coal sold for \$60 per ton, and is now probably much higher. The only available source of fuel power for a steel plant being electricity generated by water power. We had a small surplus of power over the amount contracted for so we decided to utilize it in a small electric furnace.

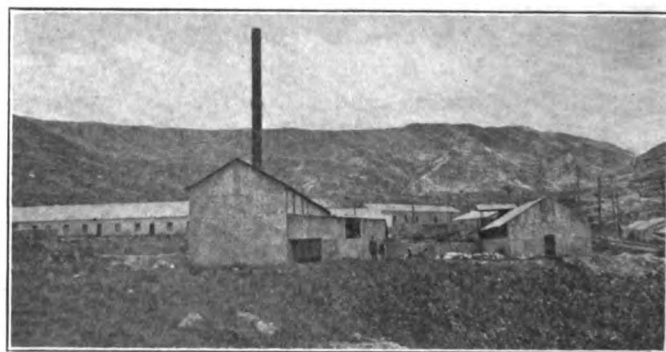
This is to our knowledge the first electric furnace to be erected in South America for refining and casting



Half ton Wile electric furnace.

rates must be added. Such were the obstacles encountered in erecting a smelter for tin ores in Bolivia.

After being in Bolivia for a short time we soon realized the extreme hardship encountered by the miners when in need of repair parts for machinery. Although



Electric furnace building in Bolivia.

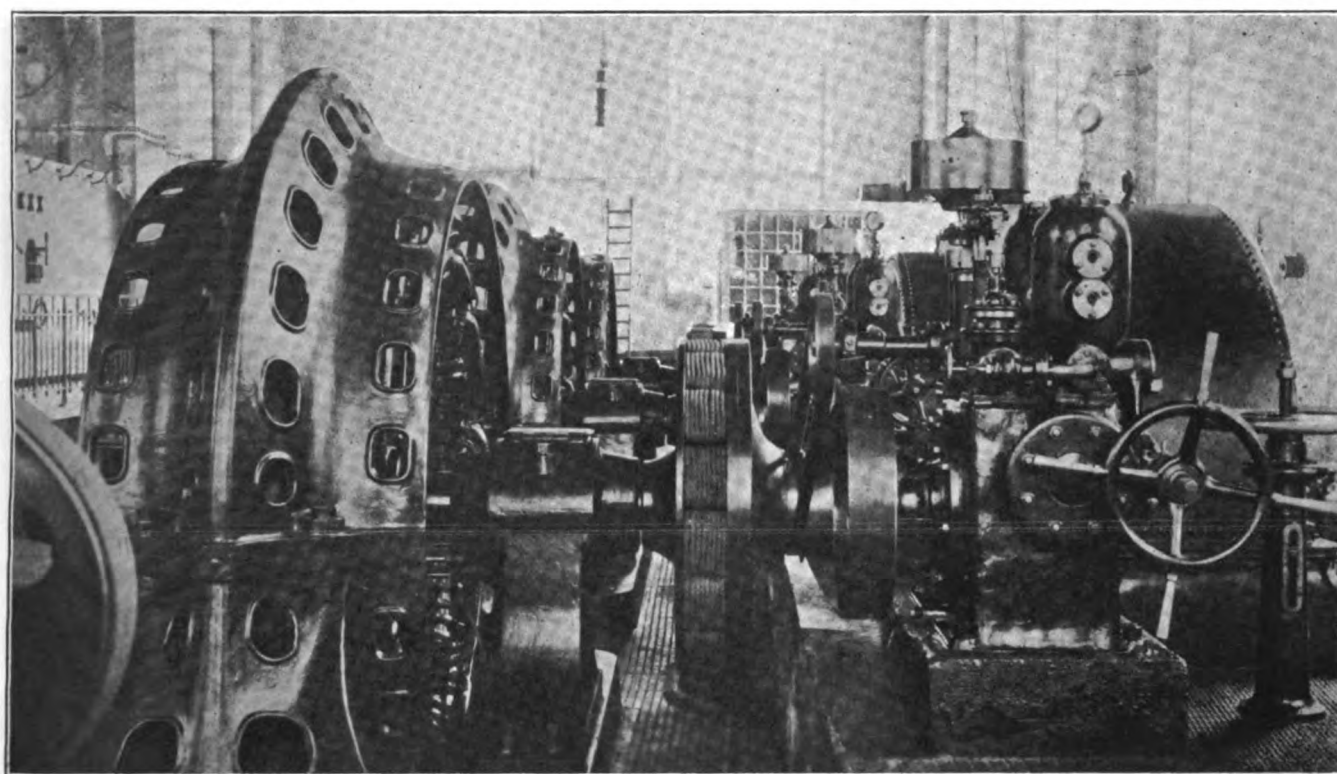
steel. Because of the difficulties already mentioned in obtaining supplies from the United States we decided to build the furnace in Bolivia, and it can very easily be conjectured that a few difficulties were to be encountered and overcome. The trouble and effort, however, were

compensated by the saving in time. Arrangements were made with an existing foundry to take charge of the furnace construction, together with the manufacture of castings and other necessities, the furnace, however, being located at our plant instead of at the plant of the foundry.

Drawings were made for a half-ton furnace and work commenced. The chief difficulty expected was in securing electrical equipment, but a French power company came to the rescue by offering us some spare equipment. The original design called for a 75 kw, three phase, air cooled transformer, but inasmuch as only a 50 kw was available, this had to be used. All meters, oil switches and small transformers were of French

laneous scrap broken as fine as possible, hand regulation of the furnace being necessary because of inability to obtain automatic regulators, and when melted the carbon is reduced with tungsten content in the steel. Some juggling is necessary, but a fairly close result is obtained.

It must be understood that in that far-off country where mining is practically the only industry, no magnesite bricks, ferrotungsten, nor other necessities for electric furnaces or steel refining were available; and though some of the things required were ordered at the very start, these had not arrived when the furnace was ready for operation and substitutes were necessary. When an alloy steel was to be made the ore containing the particular alloy was used, the results being fairly satisfac-



Water power operated generators.

manufacture and much more elaborate in design than those manufactured in this country.

The furnace was completed and ready for operation in May and in the very first heat one phase of the transformer burned out. The charge had to remain in the furnace until the transformer was repaired, which was about four days later. The results were equally unsatisfactory the second time, the same coil giving away toward the end of the heat, leaving the charge as before. The power company had a three phase, air cooled transformer of 180 kw capacity, but of 500 volts. The coils of this were opened to reduce the voltage to 90, but upon trial the voltage was found to be 135, so another change had to be made. This one proved satisfactory and operations were resumed with better results.

The furnace is started with a cold charge of miscel-

tory, but the absence of proper linings gave considerable trouble. Not even a good grade of dolomite could be secured and the bottoms had to be made of lime rammed with tar and old slag and then burned in. This had to be constantly renewed and patched, but withal it was possible to make steel at a good profit much below the price of imported steels. The laboratory used for the tin plant also served for the steel furnace, so that it was possible to keep a close check on the quality of the steel.

Tungsten ores which form a large part of Bolivia's exports can be purchased much cheaper than ferroalloys imported from foreign countries, hence they were used to a great extent in all steels for mills with a consequence that a very strong and tough steel was made.

The growth of the plant will depend to a great extent on the available power.

PRODUCTION TOPICS

ELECTRIC ETCHING OF STEEL.

According to the "Scientific American," an electric pencil or "etchograph" for writing or drawing on a piece of steel, so that the marking is etched deeply and permanently, has been perfected by William Brester, of New York City. The device consists of a pencil member and a step-down transformer which can be connected to an alternating-current socket. From the secondary or low-voltage side of the transformer one lead is connected to the work, the other to the pencil member. The pencil has a hard-rubber handle and a metal clamp which holds a short length of ordinary copper wire.

As the electric pencil is drawn over the steel surface of the work, great heat is developed at the point of contact. The etching depth can be readily varied by means of a rheostat. Operating on a 110-volt, 60-cycle circuit, the transformer requires a current of $1\frac{1}{2}$ to 2 amperes and delivers about 20 amperes at two volts to the copper point of the pencil. It is said that the "etchograph" is adapted to marking either iron or steel, and all classes of high-speed carbon and machine steel, whether in the hardened or soft condition.

PRODUCTION OF PLUMBAGO CRUCIBLES.

According to an article in a recent issue of the "Engineering and Mining Journal," the manufacture of plumbago articles has been seriously affected by conditions due to the present war. The disturbances have extended to the users of crucibles, involving increased costs and in some cases reducing output because of the shortage of crucibles of the proper quality.

The important and essential ingredients of plumbago crucibles are the plumbago and the clay which serves to hold the crucible together during manufacture and in use. The supply of plumbago comes largely from the Island of Ceylon. In October, 1914, the British government placed an embargo on plumbago exports from Ceylon lasting more than four months. This exhausted the reserve stocks of American manufacturers. After the embargo was raised shipments were generally regular enough to meet requirements except for short periods. Before the war all the clay for plumbago crucibles was imported almost exclusively from the town of Klingenberg, in the western part of Germany. The clay is remarkably clear and uniform, and the deposit large enough to supply all demands that have been made upon it.

Soon after the war Germany prohibited the shipment of this clay, and it became necessary to find a substitute. In trying out different mixtures the plan was adopted to make trial lots of six crucibles from each blend of clay. As it takes from two or three months to make and burn crucibles and get results from tests of users, progress is slow. While before the war 25 to 30 heats were secured from each crucible, the first use of domestic clays gave only four or five. At present, however, 15, 20 and 25 heats are obtained from an average size crucible, such as No. 80, used in standard rolling-mill practice. By a process of elimination the clays now in use are comparatively few, and a steady improvement is expected in the quality of crucibles. However, the cost of the domestic clay is more than double that of the German clay.

OPEN HEARTH STEEL WORKS.

At the September meeting of the Iron and Steel Institute of England, an interesting report was presented by the committee appointed to inquire into metallurgical and mechanical practice in open hearth steel works. The report was based on the replies received from a questionnaire prepared by the committee.

The replies indicated that among the contributing factors for greater output in countries outside of the British Empire were: improvement of refractories; shortening of time occupied in fettling and cooling furnaces; quicker charging; use of larger tapholes. The large proportion of scrap used by plants in these other countries was said to increase the output materially in cold-charged basic furnaces when used with pig iron having not more than 0.15 per cent of phosphorus, 0.75 per cent silicon, 4.0 per cent manganese, and 0.05 per cent sulphur. Four-tenths per cent silicon, 1.8 per cent phosphorus, 0.06 per cent sulphur and 1.25 per cent manganese would be permissible in hot-metal furnaces.

The design of the furnaces, size and processes used for the production of steel was said not to be deciding factors for output since under comparable conditions, production in England was greatly inferior to that in other countries. It was a general opinion that gas producers, which are given more attention outside of the United Kingdom, were an important factor in the consideration of output. The necessity of a sufficient supply of gas, with less than 10 per cent carbon dioxide, was emphasized.

An interesting method of working charges of all molten metal in the basic open-hearth process was described. Very little limestone and oxide were charged in the furnace before the metal, but after the molten metal was charged in the furnace, limestone and oxide was fed in continuously, flushing off the first impure slag. A 50-ton charge has been tapped in 7 hours and 20 minutes after starting to charge in this process.

SERVICE OVERSEAS.

Men are wanted for early service overseas. The men in the front-line trench need the help and coöperation of skilled men back of the lines, and men are wanted at once for the Enlisted Ordnance Corps, National Army.

Uncle Sam is calling on our trade to come across and help his fighting men. There is a lot of work to be done over there, and the call has gone out for men between the ages of 18 and 40 who want to do their bit, and who know their job.

Modern war is a tremendous business, and the army that wins is the army which has the best equipment and the best men. The men are over there now; they are ready to go ahead, but they still need experts in our line to repair and maintain their equipment. There is a fine chance for every man who wants to help.

Write to the Chief of Ordnance, War Department, Washington, D. C.

BACK NUMBERS OF BLAST FURNACE WANTED.

Twenty-five cents per copy will be paid by THE BLAST FURNACE AND STEEL PLANT for any back numbers between and inclusive of November, 1914 and November, 1917.

Library of Congress, Periodical Division, Washington, D. C., desires copies of the March and September, 1917, issues of THE BLAST FURNACE AND STEEL PLANT.

NEWS OF THE PLANTS

BETHLEHEM POURS LARGEST INGOT MOLD.

The largest ingot mold ever made has just been poured by the Bethlehem Steel Company at South Bethlehem, Pa. Its dimensions are 15 feet 7 inches high, with a mean diameter of 91½ inches, its shape being octagonal and corrugated. At its thinnest section or point of corrugation the thickness of the metal is 15 inches, and the heaviest section being 20¾ inches. A mold of this size is made so that steel can be poured into it to form ingots large enough to be reconverted into 16-inch and 18-inch guns. A steel ingot poured in this mold will weigh 300,000 pounds, and from it tubes and jackets for the large guns will be forged. Before the mold can be used large steel bands, 12 inches wide, must be shrunk around each end of the casting after it has cooled. Because of the necessity of pouring this large mold quickly, Bessemer pig iron was melted in three large open hearth steel furnaces and the melted iron suspended in ladles over the mold at one time. A continuous runner from the ladles was made so that the iron was thoroughly mixed before entering the mold. It took 340,000 pounds of pig iron to pour the casting, not counting the 10,000 pounds needed later to fill up the sink-heads so as to take care of the natural shrinkage. The mold had to be left covered in the sand for a considerable time to completely cool. Two large 100-ton cranes were used to lift it from its pit and prepare it for transference to the open hearth department, where it will be used regularly for casting ingots.—Report in the "Journal" of the Franklin Institute.

The Empire Steel & Iron Co., of Catasauqua, Pa., is said to be planning to shut down one of its blast furnaces, owing to a shortage of coke. The two furnaces operated by the company, with total capacity of 3,500 tons a week, require about 700 tons of coke daily for operation.

The St. Louis Coke & Chemical Co., of St. Louis, Mo., is planning for the erection of a new coke plant at East St. Louis, Ill., to cost about \$10,000,000. It is said that the works will give employment to about 1,200 men for initial operations. The company is a subsidiary of the American Coke & Chemical Co., Chicago, Ill. W. G. McGuire is secretary.

Fire at No. 1 furnace of the Wharton Steel Company, of Wharton, N. J., recently caused a damage of about \$10,000. The furnace, now out of commission, will be repaired at once. The company is producing manganese at its works.

The Donner Coke Corporation, of Buffalo, N. Y., has commenced the erection of its proposed new coke plant on the Buffalo river.

The Bon Air Coal & Iron Corporation, of Bon Air, Tenn., is said to be planning to double the capacity of its furnaces. William J. Cummins is vice president.

The Tennessee Coal, Iron & Railroad Co., of Birmingham, Ala., is reported to be planning for extensive additions to its steel plant at Fairfield. The works will include a new machine shop, forge and foundry, plate and angle mills and other shops to specialize in the production of machinery and parts for ship construction. The company will also install a new converter and open hearth furnace at its Ensley works.

The Donner Steel Company, Abbott road, Buffalo, N. Y., is making rapid progress in the construction of additions to its works, to cost about \$25,000.

SHEET AND TUBE GETS PRIORITY ORDER

A government priority order for a large shipment of keg nails has been placed with the Youngstown Sheet & Tube Co. The wire nails will be shipped to the American International Shipbuilding Corporation which made an urgent appeal to the Priority Board at Washington for a large shipment.

Allotment for the orders which amount to 75,000 kegs was distributed among four nail manufacturers, including the Youngstown Sheet & Tube Co. The American Steel & Wire Co. received an order for 50 per cent of the amount, and the balance will be filled by local concerns, the Jones & Laughlin Steel Co. and the Pittsburgh Steel Company.

The shipbuilding corporation has several plants on the Atlantic coast. The appeal to the government for wire nails was designated for use at the Hog Island ship plant.

The Midvale Steel & Ordnance Co., of Midvale, Pa., is said to be planning for the erection of a new steel mill at Weatherly, Pa.

The National Steel Products Company, of Birmingham, Ala., has filed notice of an increase in its capitalization from \$33,340 to \$80,340, to provide for expansion.

The Bethlehem Steel Company, of South Bethlehem, Pa., has filed notice of an increase in its capitalization from \$57,500,000 to \$65,000,000.

The Crucible Steel Company of America, 104 Magnolia avenue, Syracuse, N. Y., has had plans prepared for the construction of two buildings to its steel plant on Emerson avenue.

The Buffalo Union Furnace Company, foot of Hamburg street, Buffalo, N. Y., will increase the capacity of its plant on Katherine street; improvements and alterations will also be made, including the erection of a new blower and engine plant. The work is estimated to cost \$15,000.

The American Steel & Wire Co., of Trenton, N. J., is making rapid progress in the construction of a new addition to its plant, about 300 feet long.

Honorary membership in the American Society of Mechanical Engineers was conferred upon Maj.-Gen. George W. Goethels in recognition of his achievements in engineering, and ex-President Taft addressed the engineers on "The War's Call to Professional Men," at the convention of the American Society of Mechanical Engineers, held in the auditorium of the Engineers' Building, 29 West Thirty-ninth street, New York, December 4, 1917.

The International Steel Tube & Rolling Mill Co. has been organized with a capital stock of \$2,500,000, and is planning to build a 50-ton tube mill in the near future at Warren, O. The officers of the company are: O. R. Grimmesey, Warren, O., president; C. H. Hopkins, Cleveland, O., secretary-treasurer; Charles H. Olds, Roderick D. Grant and L. D. Greenfield, all of Cleveland, directors. W. H. Creahan, who built the Youngstown tube mill and formerly superintendent for Spang, Chalfant & Co., will be general superintendent of this mill.

The Erie Forge & Steel Co., Cascade street, Erie, Pa., has had preliminary plans prepared for the construction of a new steel works near the city limits. The proposed works will consist of a number of buildings, with estimated cost placed at \$5,000,000. Day & Zimmerman, 611 Chestnut street, Philadelphia, Pa., are engineers.

INDUSTRIAL SAFETY

(Continued from page 11.)

times as liable to injury as a trained man. We considered that the result of education among the new men, worked out mainly through the foremen.

"We found that lost time for the old men averaged 0.13 per day per month, while the lost time for the 30-day worker reached 2.41 days per month. Proof that injury is more serious to the new man than to the older employe is demonstrated by the records, showing that 14 per cent of the older employes, compared with 41 per cent of the new men injured, went to the hospital for treatment."

Arthur T. Morey, of the Commonwealth Steel Company, said: "Fatigue has a very close relation to accidents, and most accidents seem to occur along toward the end of the work period, morning or afternoon; more, apparently, toward the end of the day or the end of the shift. This seems to be borne out by statistics, and, to a certain extent, by our own experience.

"We expected to get some relief from accidents when we adopted the eight-hour day, but one factor entered into it in some way and interfered with this desirable condition. We work three shifts as we have to run our shop 24 hours, upon a furnace proposition. To get three shifts we had to cut down the luncheon time from half an hour to 15 minutes. I think we have lost something of the lessening of fatigue by the reduction, but we have not had the condition in operation long enough to speak with any scientific accuracy.

"Men like to work where conditions are the best, and under normal conditions an eight-hour shop is a very desirable place, but we have not given the experiment a fair trial; there have been so many conflicting interests.

"The matter of wages has attracted a certain amount of floaters, 'bummers' as we call them, and while we have done much to stabilize the tradesmen, we have not accomplished nearly as much as we should have, I feel, in the matter of stabilizing what we call the laborers. Human nature is pretty much alike in all of us, and we know that better and safer shop conditions attract men. I am a firm believer that an eight-hour day, with all the conditions we get into our shop, very materially tends to decrease labor turnover."

"The history of the National Safety Council reads almost like a fairy tale," concludes General Manager Cameron. Half a dozen years ago a group of iron and steel electrical engineers met at dinner in Milwaukee, and the discussion turned from production to "conservation," just then the keynote of every public gathering.

Production sufficed as a topic for a time, but "production" soon gave way to a discussion of the human element and 'conservation of human life in industry,' although we did not give it just that name at the time, and the nucleus of the organization was formed on the spot.

"When I recall the first months of the organization, with its score or two of members and a fund raised that first evening by pledges of the iron and steel engineers of \$1,400, a glow goes all over me. We had an idea and an unbounded enthusiasm and we hammered it home, one member at a time, and called a national convention for the following year in New York. We had several hundred delegates in attendance and were able to show practical application of the safety idea in a dozen plants, that is, we had proven our idea both from the business and humanitarian standpoint.

"The iron and steel industry was the leader in the movement and were the first to blazon the way to accident

prevention, and the cheery words and enthusiastic coöperation of those early days paved the way, not only for the success of the council, but for the work in scores of other lines of industry. Until the returns came in from the steel plants and foundries the great body of plant managers were inclined to hold aloof, but with the first volume of proceedings of the council the safety movement flourished, and each year has witnessed increases in membership and enlargement of scope of activity until today the movement has taken on the character of a crusade.

"When I referred to the success of the council reading like a fairy story I had in mind, of course, the nursery tale of Aladdin and his wonderful lamp. Well, rub the lamp of knowledge of the average plant executive, superintendent, manager or foreman, and see the shower of gold follow. Just because it takes the form of happy, safe and contended men, it is none the less gold thrice through the fires of the refiner.

"Would you cut down labor turnover and people your shops with every-day-in-the-month craftsmen; if so, stop the accidents. Do you desire employes who will obey shop rules because they want to do so rather than fear of discharge? Turn to the record of those employes who have started right at the top and taken a dose of their own safety medicine and watched its effects trickle down through the arteries of executive influence and return through the veins of the workers in the plant. Every time the blood reaches the vital organs, is classified and renewed and starts on its never-ending coursing, it carries a renewed message of hope and good will and coöperation all through the industrial plant, even to the humblest laborer in the yard and the watchman at the gate.

"And it isn't fairy gold, either. One of our members purchased a great cargo boat with the accumulation found in the fund set aside half a dozen years ago to pay accident claims arising in the ordinary course of his business as conducted at that time. Accident prevention pays the employes and pays the employe; it pays the employe before it pays the employer, and the public profits as well, but all the returns are certain and constant.

"Accident prevention is the largest single factor the civilians can contribute to win the war. We must balance the scales of industry and of war; an industrial soldier in the hospital means a soldier in the trenches only partially equipped. Armies must have steel, steel-workers must have health. Stopping accidents means more guns and more shells, a surge forward—and success."

CARBON MONOXIDE HAZARD IN STEEL PLANTS.

There are several places in a steel plant where gases containing carbon monoxide are handled and places where carbon monoxide results as a by-product of some industrial process. These localities are known to those in executive positions in these plants. A survey should be made with the view of determining whether carbon monoxide is escaping into the atmosphere breathed by workmen, and some system of regular periodical inspection instituted whereby places where gas may escape could be watched and carbon monoxide pollution guarded against. It is a comparatively simple matter to obtain samples of the air at these places, and they could therefore be taken by unskilled persons. The qualitative or the quantitative determination of the carbon monoxide content of these samples could be made with little expense.

Some Pointers on By-Product Coke Oven Operations

THE YIELD FROM COKE OVENS.

By A. D. Williams.

In estimating upon the production of by-product coke oven plants the accompanying table is convenient. It is based upon the production from a 10-ton oven operating on coking times varying from 24 to 12 hours, and can be readily modified to suit other oven capacities by dividing the tabular values by 10 and then multiplying by the capacity of the proposed oven and the number it is proposed to construct. When it is desired to compute the number of ovens neces-

sary for any output; divide the required amount of coke per 24 hours by the coke yield per oven in the assumed coking time found below the percentage of coke obtained from the coal to be used. This will give the number of 10-ton ovens required and the number of ovens of other capacities may be readily approximated.

Additional columns giving the usual yields of gas, ammonium sulphate, ammonia liquor, tar and light oil or crude benzol are given. These are based on the amount of coal coked per oven per 24 hours.

Coking time, hours.	Coke yield (2,000 lb.) tons per oven per 24 hours.							Gas at 10,000 ft. ³ per ton, 1,000 ft. ³ units per 24 hours.	Sulphate at 22 lbs. per ton, 2,000 lb. tons per 24 hours.	Liquor at 24 gal. per ton gallons per 24 hours.	Tar at 7 gal. per ton gallons per 24 hours.	Light oil at 2½ gal. per ton gallons per 24 hours.
	Coal (2,000 lb.) tons per oven per 24 hours.	65 per cent	67 per cent	69 per cent	71 per cent	73 per cent	75 per cent					
12.00	20,000	13,000	13,400	13,800	14,200	14,600	15,000	200.00	0.22000	480.00	140.00	45,000
13.00	18,460	12,000	12,370	12,738	13,107	13,477	13,847	184.63	0.20306	443.20	129.21	41,539
14.00	17,142	11,142	11,485	11,829	12,170	12,513	12,857	171.43	0.18867	411.44	120.00	38,570
14.50	16,551	10,758	11,090	11,421	11,750	12,083	12,414	165.51	0.18205	397.26	115.86	37,240
15.00	16,000	10,400	10,719	11,040	11,358	11,680	12,000	160.00	0.17600	384.00	112.00	36,000
15.50	15,483	10,063	10,374	10,684	10,993	11,303	11,613	154.83	0.17032	376.61	108.38	34,837
16.00	15,000	9,750	10,050	10,350	10,649	10,950	11,250	150.00	0.16500	360.00	105.00	33,748
16.25	14,769	9,600	9,895	10,191	10,485	10,782	11,078	147.69	0.16246	354.48	103.37	33,230
16.50	14,546	9,454	9,746	10,037	10,327	10,618	10,910	145.46	0.16000	349.11	101.82	32,726
16.75	14,329	9,307	9,600	9,887	10,172	10,459	10,747	143.28	0.15760	343.90	100.30	32,239
17.00	14,118	9,177	9,459	9,741	10,023	10,307	10,589	141.18	0.15529	338.83	98.82	31,763
17.25	13,913	9,044	9,321	9,601	9,878	10,157	10,435	139.13	0.15304	333.95	97.39	31,303
17.50	13,714	8,915	9,189	9,463	9,736	10,011	10,286	137.15	0.15086	329.16	96.00	30,856
17.75	13,522	8,789	9,060	9,330	9,599	9,871	10,141	135.22	0.14873	324.51	94.65	30,422
18.00	13,333	8,667	8,933	9,201	9,466	9,734	10,000	133.33	0.14667	320.02	93.33	30,000
18.25	13,151	8,549	8,811	9,075	9,336	9,600	9,864	131.51	0.14465	315.63	92.06	29,588
18.50	12,973	8,433	8,692	8,952	9,210	9,470	9,731	129.72	0.14270	311.37	90.81	29,188
19.00	12,632	8,212	8,463	8,716	8,968	9,221	9,474	126.32	0.13895	303.16	88.42	28,421
19.50	12,308	8,001	8,247	8,493	8,738	8,985	9,232	123.00	0.13538	295.40	86.76	27,692
20.00	12,000	7,801	8,040	8,280	8,520	8,760	9,000	120.00	0.13199	288.00	84.01	27,000
21.00	11,428	7,429	7,657	7,886	8,114	8,343	8,572	114.28	0.12571	274.30	80.00	25,713
22.00	10,909	7,092	7,309	7,528	7,746	7,963	8,183	109.09	0.12000	261.83	76.37	24,544
23.00	10,436	6,783	6,992	7,201	7,409	7,618	7,827	104.35	0.11477	250.43	73.05	23,478
24.00	10,000	6,500	6,700	6,900	7,100	7,300	7,500	100.00	0.11000	240.00	70.000	22,500

Based on 10-ton oven—Multiply values by number ovens × 0.1 capacity of oven.

10-Ton oven production: Coke, gas, sulphate, tar, benzol, 1 deg. F.

(Table supplied by courtesy of the Gas Machinery Company, Cleveland, O.)

COOKING OF ILLINOIS COALS.*

So far as is known commercial coke is not at present being made from Illinois coal in either beehive or by-product ovens, although a small amount is made in gas retorts as a by-product from the manufacture of illuminating gas. In its endeavor to promote a more efficient use of coal, the Bureau of Mines, in coöperation with the Illinois State Geological Survey and the University of Illinois, has undertaken an investigation of the coking of Illinois coal.

The results of the investigations show that with by-product coke ovens coke for fuel can be made from Illinois fuel alone, and that from mixtures of Illinois coal with low-volatile coking coal, coke can be made for metallurgical use. Tests were made with both beehive and by-product ovens with 20 to 100 per cent Illinois coal.

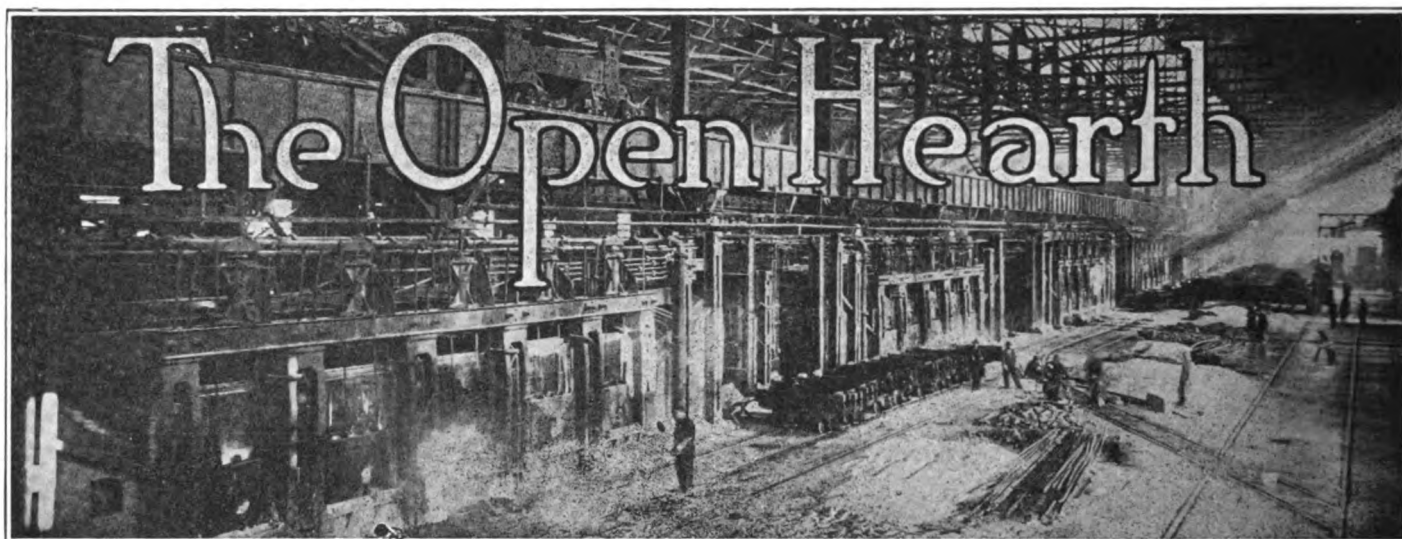
Coke made from Illinois coal alone proved to be inferior to coke from eastern coals. The structure was fairly uniform, cells were small and numerous and the cell walls thin. The

coke had a tendency to break in pieces about 6 inches long and 2 inches in length.

The use of 20 to 30 per cent of Illinois coal mixed with a low-volatile coal for making metallurgical coke offers promise of success. Coke made from mixtures of 20 per cent Illinois coal and 80 per cent low-volatile coal was used in blast furnaces for several consecutive weeks with satisfactory results. Possibly the proportion of Illinois coals can be increased to 30 per cent or more, but the use of even 20 per cent in all the by-product coke ovens near the Illinois coal field would mean a large annual consumption. The by-product ovens within a short distance of this field consume 9,000,000 tons of coal annually.

By adding a low-sulphur eastern coal to Illinois coal, coke with a sulphur content for blast furnace purposes can be obtained. If 80 per cent of eastern coal containing 0.7 per cent sulphur is used, the 20 per cent of Illinois coal can contain 2 per cent of sulphur without the sulphur content running over 1 per cent. A large amount of Illinois coal contains less than 2 per cent sulphur and hence would be available for use in such mixtures.

* From Bureau of Mines bulletin 138, by F. K. Ovitz.



LEWIS A. WAY.

Lewis A. Way is now assistant to the president of the Lewis Foundry & Machine Co., Pittsburgh, Pa. He was formerly superintendent of the Duquesne Steel Foundry Company of the same city.

V V

Frank L. Estep, formerly chief engineer of the Tennessee Coal, Iron & Railroad Co., is to become chief engineer of the Nova Scotia Steel & Coal Co. He has been connected with the Tennessee Coal, Iron & Railroad Co. for eight years, previous to which time

he was with the Cambria Steel Company, Johnstown, Pa.

V V

F. W. Claflin, of Perin & Marshall, New York, has sailed for Sakchi, India, to erect the dismantled blast furnace which is being shipped from Battelle, Ala. The furnace will be operated by the Tata Iron & Steel Co.

V V

Charles Piez recently resigned as president of the Link-Belt Company, elevating, conveying and power-transmission machinery, to become vice president of the recently organized Emergency Fleet Corporation. Mr. Piez has been associated with the Link-Belt interests since he entered as draftsman of the Link-Belt Engineering Company, Philadelphia, Pa., in 1889, becoming successively chief engineer, general superintendent, and general manager until 1906, when he became president of the Link-Belt Company, a merger of the Link-Belt Machinery Company, Chicago, Ill.; Link-Belt Engineering Company, Philadelphia, Pa., and the Ewart Manufacturing Company, Indianapolis, Ind.

V V

R. B. Richards, who was superintendent of the West Virginia & North Western Iron Co., Mayville, Wis., is now with the Tenth Battalion, One Hundred and Sixtieth Depot Brigade, Camp Custer, Mich.

V V

George A. Miller, who for the past three years has been superintendent of the Bessemer rolling mills of the Tennessee Coal, Iron & Railroad Co., Bessemer, Ala., is supervising the erection of the new steel mills at the Fairfield works of the same company.

V V

L. W. Adams, of Bethlehem, Pa., has recently been appointed general superintendent of the Nova Scotia Steel & Coal Co.'s Trenton, N. J., plant.

E. K. Miller, who was formerly engaged in furnace practice work at the Ensley plant of the Ensley blast furnaces of the Tennessee Coal, Iron & Railroad Co., has been appointed assistant superintendent of the Oxmoor furnaces of the same company at Oxmoor, Ala.

V V

D. J. Angus, who has been identified with many of the large electrical developments of the Middle West, is now treasurer of the Esterline Company, Indianapolis, Ind., and will assume charge of the engineering department of this well-known firm of engineers and manufacturers. Mr. Angus designed the world's largest electric meter for the Mississippi River Power Company at Keokuk, Iowa.

V V

W. J. Smith succeeds George A. Miller as superintendent of Bessemer rolling mills of the Tennessee Coal, Iron & Railroad Co. Mr. Smith has been connected with the rolling mill for a number of years as chief roll designer and assistant superintendent.

V V

Vere Brown has been appointed general manager of the Allegheny Steel Company, Brackenridge, Pa., to succeed W. Lester Brown, who died recently. Mr. Brown has been with the Allegheny Steel Company since 1909, when he entered the metallurgical research department, having been formerly employed in the metallurgical department of the Dominion Iron & Steel Co., Sydney, N. S. Wales. In 1914 he became assistant general manager, in which capacity he has served until the recent promotion.

V V

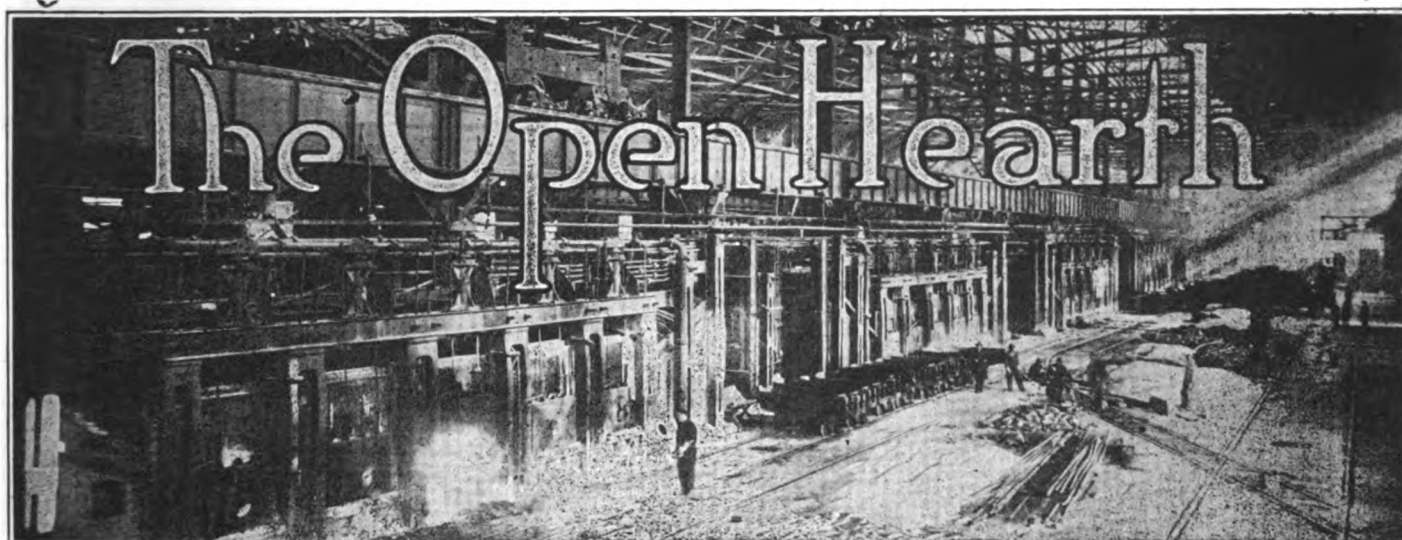
F. W. Claflin, of Perin & Marshall, consulting engineers, will superintend the erection at Salchi, India, of the blast furnace recently dismantled at Battelle, Ala. The Tata Iron & Steel Co. are planning to utilize this furnace for the production of ferromanganese.

V V

H. J. Moore, until recently assistant master-mechanic, Central furnace, American Steel & Wire Co., is now superintendent of the high-tension power lines between the Newburg and Central works of the company.

V V

R. F. Main, until recently in charge of the Dayton laboratory of the Charles C. Kawin Company, has been appointed director of the laboratories of that company at Dayton, Chicago, San Francisco and Toronto, Ont. Mr. Main was engaged in laboratory work for the Illinois Steel Company, Chicago, Ill., and the Upson Nut Company, Cleveland, O., before coming to Dayton in 1914.



J. Frater Taylor has announced his intention to resign from his position as president of the Algonia Steel Corporation, Sault St. Marie, Ont. His resignation will take effect January 1.

✓ ✓

Roy M. Welch, who has been connected with the Youngstown Sheet & Tube Co., Youngstown, O., since 1902, has been named assistant to President Campbell.

✓ ✓

E. P. Perkins, formerly superintendent of the plate mill department of the Allegheny Steel Company, Brackenridge, Pa., is now assistant general manager, succeeding Mr. Brown, who is now general manager in place of W. Lester Lee, who died October 7.

✓ ✓

J. F. Adey, formerly superintendent of construction for Stone & Webster at the plant of the Brier Hill Steel Company, Youngstown, O., is in France superintending the extensive engineering work which Stone & Webster is performing for the United States government there.

✓ ✓

John A. Green is now foundry superintendent for the Pittsburgh Crucible Steel Company, Midland, Pa.

✓ ✓

A. M. Knight, formerly chief chemist of the John Deere Company, Moline, Ill., succeeds R. F. Main as head of the laboratory of the Charles C. Kawin Company, Dayton, O.

✓ ✓

Capt. William H. Johnson, Ishpeming, Mich., for 41 years associated with various subsidiaries of the United States Steel Corporation, retired from active business on January 1, 1918. Capt. Johnson retires at the age of 71, after a lifetime of active work in the steel industry.

✓ ✓

Sherwood H. Standish, formerly assistant superintendent of the Northwestern Malleable Iron Company, is now works manager of the Stowell Company, South Milwaukee, Wis.

✓ ✓

N. A. Alderdice, formerly with the Carnegie Steel Company, Pittsburgh, Pa., is now located with the National Tube Company, Lorain, O.

✓ ✓

Alex. L. Field, formerly of the Bureau of Mines, is in charge of the research laboratory of the Powdered Coal Engineering & Equipment Co., Chicago, Ill.

Walter C. Allen, president of the Yale & Towne Manufacturing Co., New York, is anticipating a commission as major in the signal corps. Mr. Allen has been granted a leave of absence to enable him to offer his services to the government, and he expects to sail for France shortly.

✓ ✓

C. Birdsall Smith, who was until recently treasurer of the Cleveland Furnace Company, Cleveland, O., has gone into partnership with Edworf S. Bassett, business and financial councillor, 1021-23 Guardian Building, Cleveland, O.

✓ ✓

Leroy F. Hamilton, formerly manager of the advertising and specialty department of the National Tube Company, Pittsburgh, Pa., assumes the duties of manager of sales promotion with the Walworth Manufacturing Company, Boston, Mass. Mr. Hamilton has been affiliated with the Kewanee works since the days of the Western Tube Company, which was taken over in 1908 by the National Tube Company which in turn sold out to the Walworth Manufacturing Company last August.

✓ ✓

N B. Payne has opened an office in the Havermyer Building, 25 Church street, New York, where he will handle new and used traveling cranes. Mr. Payne was formerly with Manning, Maxwell & Moore, Inc., New York.

✓ ✓

F. S. Rutherford, formerly district sales agent for the Youngstown Sheet & Tube Co., at Denver, Colo., has resigned to sail for France as a Y. M. C. A. secretary.

✓ ✓

William F. Bailey, who has been acting as assistant to the president of the Midvale Steel & Ordnance Co., Philadelphia, Pa., has recently resigned from that position.

✓ ✓

J. H. Plummer has recently been appointed as a member of the honorary advisory council for scientific and industrial research of Canada. Mr. Plummer is a director of the Dominion Steel Corporation.

✓ ✓

G. W. Pratt, of the sales department of the Midvale Steel & Ordnance Company, at the Toledo office, has been transferred to the Cleveland office of the same company.

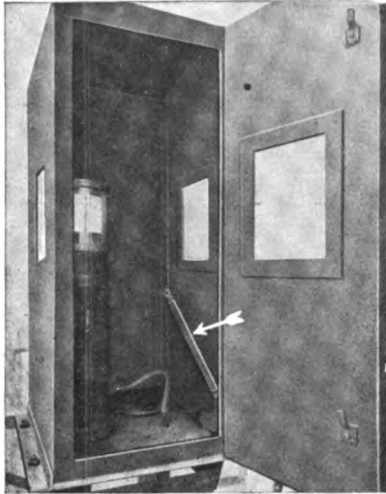
✓ ✓

J. C. Bannister, who was recently in charge of the Kewanee works of the Walworth Manufacturing Company, Boston, Mass., has been made vice president of the company. Mr. Bannister will continue in charge of the works at Kewanee, Ill., which were purchased from the National Tube Company last August.

WITH THE EQUIPMENT MANUFACTURERS

ELECTRIC HEATER FOR CRANE CABS.

The Cutler-Hammer electric space heater unit marketed last fall to the industrial plants (particularly the steel mills) has now been put up in cartons of 10 each. Users have found it desirable to carry such standardized heating units in stock, since uses for them frequently arise during the cool months of the year.



Showing an application of the Cutler-Hammer space heater unit in a coke plant.

The cartons are labeled and stamped with the voltage (115, 230 or 250) for which the units contained are designed. The accompanying illustration shows the new unit installed in the gas valve house of the coke plant of the Corrigan-McKinney Co., Cleveland, O. The unit is mounted against the side near the floor. Another in this same plant, besides those in the crane cabs, is located in the meter house on the charging bridge of the coke oven. It is obvious that electric heat provides the most flexible means of heating in such detached and remote places. The units illustrated are of 500 watts capacity and are made by The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.

A SAFETY-FIRST SWITCH THAT IS FOOLPROOF.

A year or so ago when the General Electric Company of Schenectady, N. Y., first marketed lever switches enclosed in safety-first iron casings, the pulse of the electrical world responded to the protective advantages offered; orders exceeded expectations; the success of the product was assured. The designing engineers, however, did not neglect experimentation which might better both the performance and purpose of the switch. Now they have placed in production another type which is considered foolproof.

The switch is mounted on a slate base and completely enclosed in a metal casing. A padlock at the bottom prevents any "outsiders" tampering with the enclosed fuses. The switching lever cannot be closed while the covering over the fuses is open, and vice-versa.

It was at first thought that this interlocking arrangement would give sufficient protection, but several new conditions have gradually come to light. For instance, where two or three operators are involved it has been observed that although one of them may throw on the switch with perfect safety, he may at the same time endanger another operator working on a machine whose motor gets its current through the switch. To meet this condition three locks, each controlled by a different individual, may be used and all operators kept thoroughly in touch with what is going on. By special order these switches will also be provided with spring catches which must be pressed down while the switching lever is moved. Both hands are thus

required to switch the electricity on or off and further safety is achieved.

Because this new development is so thoroughly "fool-proof" modern practice makes its use very advisable wherever "front-connected" knife switches are required.

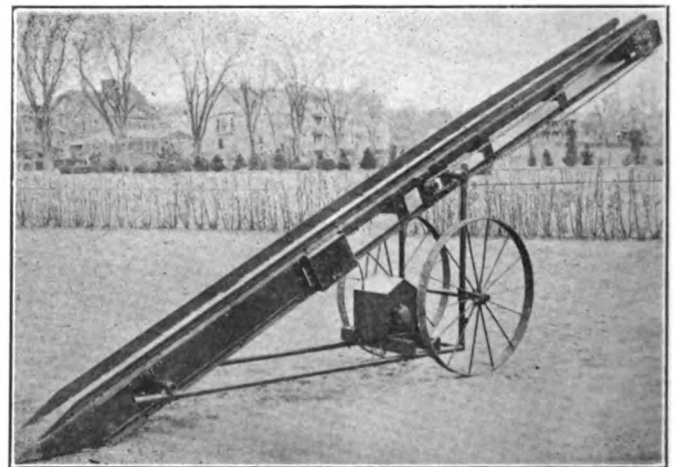
PORTABLE SCOOP CONVEYOR.

A new type of portable belt conveyor which has found a ready market is manufactured by the Portable Machinery Company, Inc., of Passaic, N. J.

The machine is operated either by electric motor or gasoline engine and is known as the scoop conveyor, because the conveying belt receives its material through a scoop which can be pushed or completely buried into the material to be conveyed.

The object of the scoop conveyor is to provide a portable machine that can be readily handled by one man for the purpose of loading and unloading and stacking and reclaiming loose materials, such as coal, coke, ashes, crushed stone, sand, gravel, etc.

The manufacturers claim that it will also handle sacks, packages, boxes and various manufactured products, and that



one man and the scoop conveyor will handle loose materials at the rate of one ton in one and one-half minutes.

The illustration shows the construction of the conveyor, which is completely made of steel and so light that by inserting two pieces of pipe in the horizontal members, shown in the illustration, a man may move it about as easily as he would move a wheelbarrow.

Keeping cars and trucks moving and cutting cost of hand shoveling is a necessity under present-day operating conditions, and a large number of well-known concerns are already using anywhere from 1 to 10 of these machines for this purpose.

PORTABLE BELT CONVEYOR.

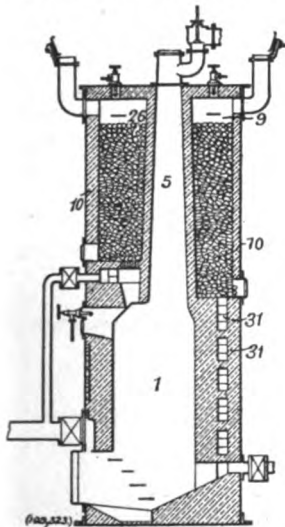
The Barber-Greene Company, Aurora, Ill., have developed a portable belt conveyor which should enjoy an extended use.

It is a self-contained apparatus with an electric motor mounted within the frame, which is of special construction, combining the requisite strength with lightness sufficient to make the conveyor readily portable. These features make a machine that may be adapted to a wide variety of uses.

RECENT PATENTS

Gas Producers.

109,323. C. B. Tully and O. E. Yeo, Westminster, England. An English patent has been granted for the gas producer of the illustration. The essential parts of the producer are a gas-generating chamber 1 which communicates with a full-supply chamber 5; a steam-generating chamber 9, containing refractory material arranged between the outer wall 10 and the fuel-supply chamber 5; and, in communication with 5, a steam-superheating chamber 31, which opens at its lower end to the generating chamber 1. For manufacturing enriched gases an oil-cracking chamber 26 is provided. The arrangement is such that during the blowing stage, gas produced by passage of air more or less horizontally only through a small depth of the fuel in the bottom of the gas-generating chamber, and composed mainly of carbon dioxide



and nitrogen, will pass upward through the steam-superheating chamber or passage and steam-generating chamber, and that gas produced by air passing either simultaneously or subsequently upwardly through the mass of incandescent fuel, and composed mainly of carbon monoxide and nitrogen, will pass through the oil-cracking and superheating chamber and be burnt therein.

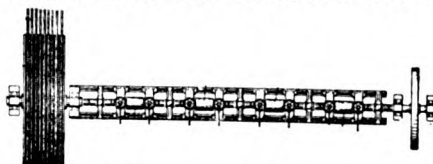
Stack Cleaner.

1,249,483. Dujo Plavsa, Butte, Mont. Filed July 9, 1917. A device of the class described comprising a cylindrical stack, a spired secured adjacent the top thereof, a bracket secured adjacent the bottom of the stack, a shaft centrally journaled through the said spider and bracket, a wind-engaging plate upon the upper end of the said shaft scrapers upon said shaft in substantial contact with the sides of the stack, a disc anti-frictionally journaled upon said bracket and through which said shaft freely extends, a circular cam upon said disc concentric with

the shaft, an arm upon the shaft, and a roller journaled upon the said arm positioned and adapted for traveling upon the said cam.

Rolling Mill.

1,248,644. William Gildersleeve, Martins Ferry, O. A flywheel placed at the end of a set of rolls, arranged in a train,



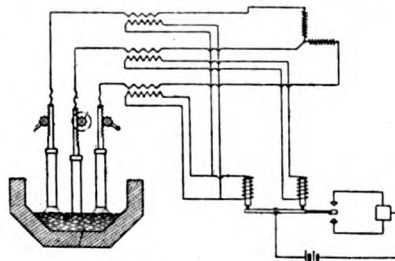
is the novel feature of this invention. By means of the flywheel back-lash is prevented and the liability to damage resulting from the breakages of a roll is lessened.

Pressure Regulator.

1,249,934. Ralph C. Enqart, Connersville, Ind., assignor to the P. H. & F. M. Roots Co., Connersville, Ind. A pressure regulator comprising a fixed horizontally disposed diaphragm casing, a diaphragm therein, a vibratable horizontal lever disposed under the casing and connected with the diaphragm, a cylinder formed with a closure at one end and provided at its other end with means for securing it against the casing to close the opposite end of the cylinder, said lever passing freely through mortises in the wall of the cylinder, and a double-ended piston disposed in the cylinder and provided between its ends with a mortise engaging the lever combined substantially as set forth.

Polyphase Electric Furnace.

1,248,632. Joseph Lawton Dixon, Detroit, Mich. This patent comprises in a polyphase electric furnace, the combination with a crucible for containing a mass of material to be treated, of three electrodes connected up in a two-phase three-



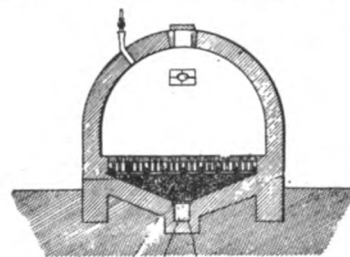
wire system of current supply, means for adjusting the position of the common return electrode, and two opposing electro-magnets for controlling the operation of the same, energized normally and equally by current proportional to that through the return electrode and the vectorial sum of the currents proportional to those through the other electrodes.

Method of Etching Metals.

1,248,499. Jesse L. Jones, Oakmont, Pa., assignor to Westinghouse Electric & Manufacturing Co. The method of etching metals that comprises immersing the metal to be etched in a molten metal of lower melting point that is capable of alloying with the metal to be etched, agitating the said molten metal, removing the etched metal from the molten bath, and cleansing the said etched metal.

Coke-Producing and By-Product Recovery Method.

1,248,883. Matthew Marshall, Sr., Port Coquitlam, British Columbia, Can. The method of producing coke and recovering the by-products thereof consisting in inducing a downward draft through a heated charge of coal whereby the heat from the upper strata of the charge is



drawn downward through it and the volatile constituents are given off, then passing such constituents downwardly in separate streams and then through a finely divided material to the condensers.

Hot Blast Stove.

1,249,701. Frank L. White, Pittsburgh, Pa. Filed July 27, 1917. A hot blast stove having a cleaning opening leading to the interior of the stove in combination with removable means for effecting communication between said opening and the stove stack, said means being removable from in front of said opening to afford access thereto in cleaning the stove interior, and said opening forming the orifice through which the waste gases of combustion pass from the stove to the stack.

Process of Producing Steel in Side-Blown Converters.

1,249,075. John H. Hall, New York, N. Y., assignor to Taylor Wharton Iron & Steel Co., High Bridge, N. J. This invention provides in the pneumatic process of making steel, the improvement which consists in subjecting to lateral air blowing a feruginous mixture in which the silicon and manganese are present in such quantity and are so proportioned that by their oxidation there is produced a workable fluid slag containing approximately 60 parts of MnO to every 40 parts of SiO₂.

Trade Publications

Industrial Motors—The second of a series of catalogues of industrial motors has just been distributed by the Westinghouse Electric & Manufacturing Co. of East Pittsburgh, Pa. This is known as catalogue 30 and covers the company's complete line of direct-current motors and generators for industrial service.

After several pages giving general information regarding the ordering, classification and selection of direct-current motors, there follows complete description, rating and dimensions for type SK commutating-pole motors, various modifications of type SK elevator motors, reversing planer motor equipment, type CD motors, headstock equipment for wood-working plants, type SK and CD motor-generators and arc-welding equipment. Much new information is given especially on such subjects as arc-welding, headstock equipment, motion picture service and battery charging service.

The new catalogue is identical in size and will fit the binder for the company's line of catalogues covering supply apparatus and small motors.

Rehandling Buckets—A folder describing the "Blaw" speedster bucket has just been issued by the Blaw-Knox Company, Pittsburgh, Pa. This bucket is described as the lower-arm type and is said to be especially suited for use in loading and unloading barges and cars and for transferring materials to and from stock piles.

Electric Furnaces—A new booklet, Electric Furnace Bulletin No. 40, has been issued by the Industrial Electric Furnace Company, Chicago, Ill. It is descriptive of the Snyder furnace and is well illustrated.

Heat-Resisting Metal—The Diamond Power Specialty Company, Detroit, Mich., has published bulletin No. 118, describing "Insuluminum," their new heat-resisting alloy. The results of "calorizing," as they call the process of impregnating iron and steel with an aluminum alloy, are shown by photographs and photo-micrographs of articles so treated.

Cable-Way Carriages—A well illustrated folder descriptive of the "Blaw" locking cable-way carriages has been recently published by the Blaw-Knox Company, Pittsburgh, Pa.

Electric Furnaces for Heat-Treating Shells—A bulletin describing a new type of automatic electric furnaces for the heat-treatment of shells and shrapnel has just been issued by the Electric Furnace Company, Alliance, O.

Handling Raw Materials—In a beautifully illustrated and printed booklet entitled, "What We Do," the Wellman-Seaver-Morgan Company, Cleveland, O., give a brief review of the extensive field covered by the characteristic work of the company.

Concrete Mixers—An illustrated booklet on the "Blaw-Ransomixer" is published

by the Blaw-Knox Company and shows the salient features of this concrete mixer.

Magnetic Separators—In booklet S, the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., describes their magnetic separators and gives an extended list of their applications. The booklet is exceptionally well illustrated with photographs of various installations of the separator as well as diagrams showing the operation of the apparatus.

Truck Platforms—Bulletin 37, published by The McMyler-Interstate Company, Cleveland, O., describes pressed steel platforms for hand or power elevating trucks. A short article on these platforms is included in the department, "With the Equipment Manufacturers" in an early issue of THE BLAST FURNACE AND STEEL PLANT.

Recuperative Gas Oven Furnaces—Bulletin No. 160, Tate-Jones & Co., Inc., Pittsburgh, Pa., describes the Tate-Jones recuperative type of furnaces and gives a graphical representation of the economies which may be effected by their use. The bulletin is well illustrated with diagrams of furnace construction.

Trade Notes

N. B. Payne has opened an office in the Havermeyer Building, 25 Church street, New York, as an electric crane specialist, supplying new and used traveling cranes of "certified character." Mr. Payne was formerly associated with Manning, Maxwell & Moore, Inc., New York, and has an extensive experience in this kind of work.

Charles T. Main, of Boston, Mass., a consulting engineer, who has served in several public offices for the purpose of advancing the idea of good government, has been elected president of the American Society of Mechanical Engineers. Mr. Main has designed and supervised the construction of numerous industrial, steam-power and water-power plants, among his largest undertakings being the Wood Worsted and Ayer mills in Lawrence, Mass., and four hydro-electric developments for the Montana Power Company, aggregating about 230,000 hp.

Samuel A. Benner, vice president of the Federal Export Corporation, 115 Broadway, New York, sailed in mid-December for Buenos Ayres, Argentina. Mr. Benner's tour is made necessary by the increased demand from Latin America for American steels, and his visit will comprehend an investigation covering the possible future requirements of the southern republics in these materials and supplies. Mr. Benner will also supervise the extension of the Federal export branch house system to the many trading and commercial centers throughout these countries.

H. Norman Brooke and F. H. Brooke, Sheffield, England, have acquired the exclusive right to manufacture and sell Maccallum metal-kase brick in Great Britain. The Messrs. Brooke are

large manufacturers of silica and magnesite brick, and at their Cleveland works (The Cleveland Magnesite & Refractory Co., England) are associated with Benjamin F. Talbot, managing director of the Cargo Fleet Iron Works and inventor of the Talbot process for making steel. Maccallum metal-kase brick are made and sold in the United States and Canada exclusively by the Harbison-Walker Refractories Company of Pittsburgh, Pa.

The firm of Gannestad & Jacobson has been forced by the increase in business to move from the former location, in the Benedum-Trees Building, Pittsburgh, Pa., to more commodious quarters in the B. F. Jones Building. Gannestad & Jacobson are designers of plants and machinery for iron and steel works.

H. A. Lomax, formerly with Seaman-Sleeth Company, is now manager of roll sales for the MacIntosh-Hemphill Company.

Society Meetings

Association of Iron and Steel Electrical Engineers, Philadelphia section, January 5, 1918. Paper on "Electrically Operated Bridges," by Messrs. John C. Reed and Merwyn J. Hocker, electrical engineers of Bethlehem Steel Company, Steelton, Pa. February 2, 1918, paper on "Mill Type Transformers," by Harry G. Steele, Pittsburgh Transformer Company, Pittsburgh, Pa.

American Institute of Mining Engineers, 29 West Thirty-ninth street, February 18-21, 1918.

American Society of Civil Engineers, 29 West Thirty-ninth street, New York, January 22-25, 1918.

Engineers' Society of Western Pennsylvania, Oliver Building, Pittsburgh, Pa., January 1 and 15, 1918.

Western Society of Engineers, Chicago, Ill., January 2, 1918.

The Pittsburgh section of the A. I. S. E. E. and the A. I. E. E. will hold a joint session in Pittsburgh, Saturday, January 19, 1918, when the subject of "Central Station Power" will be discussed.

National Safety Council, annual congress for 1918 will be held at St. Louis, Mo., the third week in October, 1918. Headquarters will be at the new Statler Hotel. W. H. Cameron, general manager, Continental & Commercial Bank building, Chicago, Ill.

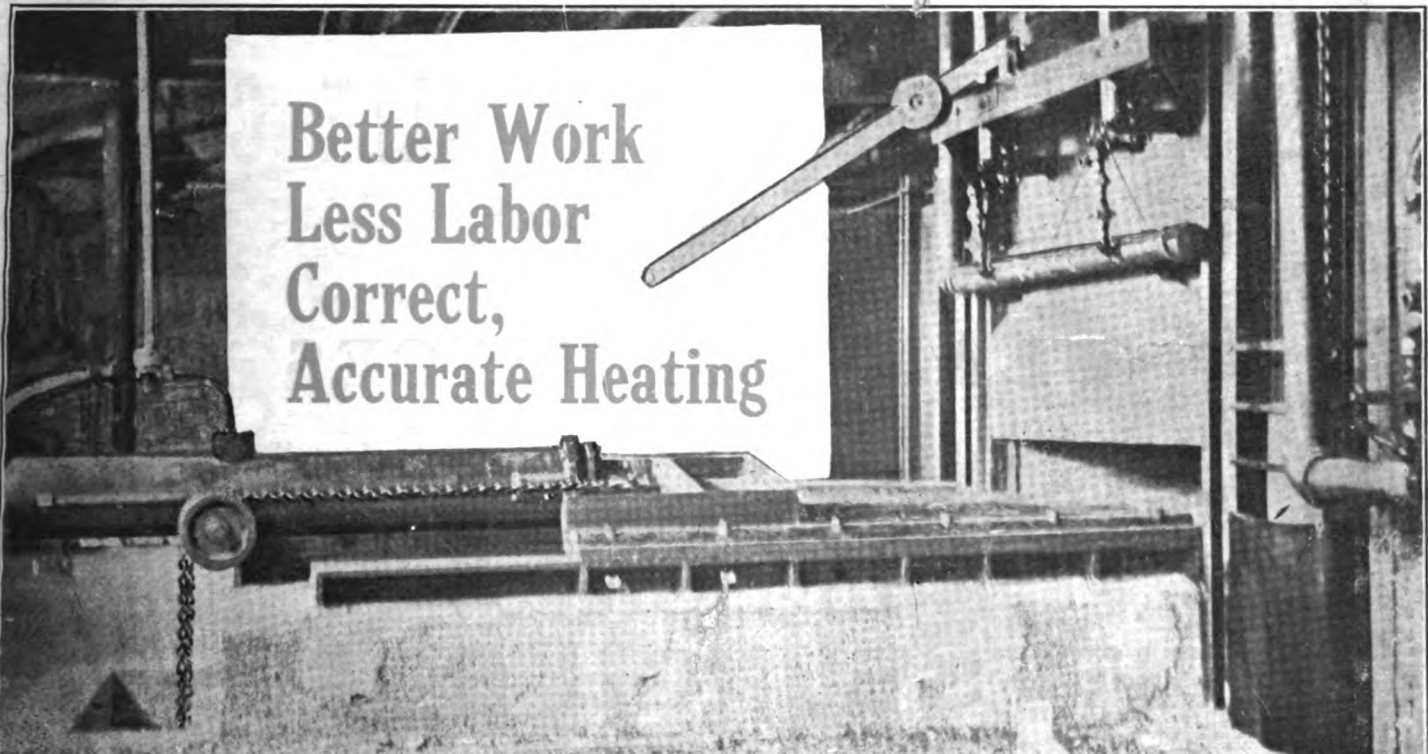
At the Philadelphia section of the A. I. S. E. E., to be held in Philadelphia, January 5, Messrs. John C. Reed and Merwyn J. Hocker, electrical engineers of the Bethlehem Steel Company, Steelton, Pa., will deliver a paper entitled "Electrically Operated Bridges."

Providence Engineering Society. Monthly meeting, fourth Wednesday of each month. A. E. Thornley, corresponding secretary, P. O. Box 796, Providence, R. I.



The Blast Furnace *and* Steel Plant

Pittsburgh, January, 1918



Better Work
Less Labor
Correct,
Accurate Heating

Allis Continuous Pair Heating Furnaces *for Sheet and Tin Plate Mills*

Heats the bars uniformly throughout to working temperature. No cold spots—No scaling. Unequal heating is impossible, every bar passes through the same heat zones.

An ordinary dragout, not a skilled heater, successfully operates the furnace. The bars are thrown on the charging table, then pushed through to the discharge end of the furnaces automatically by either an electric or hydraulic charger. Each heat progresses by easy stages and arrives at the discharge end of the furnace uniformly heat-treated to the proper working temperature. No piling or handling bars in the furnace is necessary. Makes work at these furnaces comfortable and the labor problem easy. No moving parts inside the furnace.

Low Fuel Consumption.

We have stoker fired records as low as 216 lbs. of coal to the ton of finished product. Allis Furnaces are adapted to any fuel, producer or natural gas—coal, pulverized coal, and oil.

The superior product, the increases in tonnage secured, the low fuel consumption, the saving in labor and the comfort of the operators has resulted in sixty-five of these furnaces built and contracted for in the past year by the best Sheet and Tinplate Mills in the country.

Repeat orders coming in every week show the satisfaction of the first installations.

Let our thoroughly conversant representative call upon you with full particulars.

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